NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

May 24, 2018

Computed Tomography Specialist's Factual Report

CEN17FA127

A. ACCIDENT

Location:	near Chalmers, IN
Date:	March 14, 2017
Time:	1546 eastern daylight time
Airplane:	MD Helicopters 369FF helicopter, N530KD

B. GROUP

Computed Tomography Specialist:	Scott Warren National Transportation Safety Board Washington, D.C.

C. SUMMARY

On March 14, 2017, at 1546 eastern daylight time, an MD Helicopters 369FF helicopter, N530KD, impacted terrain during a power line construction flight. The pilot was fatally injured and the helicopter was destroyed. The helicopter was registered to Robin M Rogers and operated by Rogers Helicopters, Inc., under the provisions of 14 Code of Federal Regulations Part 133 as an external load operation. Visual meteorological conditions prevailed at the time of the accident and no flight plan had been filed.

The internal configuration of the longitudinal trim actuator, lateral trim actuator, and cyclic grip were documented using radiographic images that were collected between November 1, 2017 and January 10, 2018 in Chicago, Illinois. A total of 27,647 computed tomography (CT) slice images were examined, processed, and analyzed by the NTSB to evaluate the components.

Review of the images indicated that, when the scans were conducted, the following items were noted:

Longitudinal trim actuator:

- there was a gap of 0.134 inches noted between the end of the actuator rod and the actuator spring cartridge end fixture;
- there were 2.724 inches of actuator screw thread between the actuator screw ball and the actuator screw base;
- there were no indications of failure within the actuator motor bearings or output gear train;
- there were indications of small clearances between the actuator motor wires and the motor ground terminal components and between the wires themselves;
- there were no indications of short circuits or other wiring damage within the actuator motor or circuit board wiring;

Lateral trim actuator:

- there was a gap of 0.219 inches noted between the end of the actuator spring cartridge end fixture and the actuator rod end fixture;
- there were 0.517 inches of actuator screw thread between the actuator screw ball and the actuator screw base;
- there were no indications of failure within the actuator motor bearings or output gear train;
- there were no indications of short circuits or other wiring damage within the actuator motor or circuit board wiring;

Cyclic grip and trim switch:

- there was a crack noted in the trim switch insert;
- there were multiple indications of high density particles within the trim switch;

- there were no indications of a material buildup that would have caused a short circuit within the trim switch.

D. DETAILS OF THE INVESTIGATION

1.0 General

The longitudinal trim actuator, lateral trim actuator, and cyclic grip were subjected to x-ray radiograph and computed tomography (CT) scanning to document their internal conditions. The scanning was conducted between November 1, 2017 and January 10, 2018. The scans were performed by Varex, Inc under the direction of the NTSB using the Varex Actis 500/225 microfocus CT system.

For the CT scans, the components were loaded into the imaging unit and placed on a turntable. The components were then rotated in front of the x-ray source, and the x-rays were captured by a detector after they went through the part. The x-ray source produced a cone beam of x-rays, and the portion of the part imaged was adjusted slightly after each scan was completed until the entire assembly (or region of interest of the part) was scanned. The x-ray energy levels measured by the detector were recorded at several thousand different points during each rotation, and this information was converted into slice images using reconstruction algorithms.

The components were scanned using a total of 27,647 slices, and the total size of the combined data sets was approximately 177 Gb. The complete scan protocols are given in table 1. The digital radiograph and CT axial slice images were provided by Varex to the NTSB where they were examined, processed, and analyzed to evaluate the components.

Table 1
Scan Protocols

Component	Longitudinal trim actuator – overall	Lateral trim actuator – overall	Cyclic grip – overall	Longitudinal trim actuator – motor and gear target	Lateral trim actuator – motor and gear target	Longitudinal trim actuator – printed circuit board	Longitudinal trim actuator – target	Trim switch – target
Number of slices	6711	6051	2022	2104	2206	4151	2001	2401
Voxel Size - X Direction (mm)	0.047	0.047	0.047	0.095	0.095	0.022	0.029	0.015
Voxel Size - Y Direction (mm)	0.047	0.047	0.047	0.095	0.095	0.022	0.029	0.015
Voxel Size - Z Direction (mm)	0.06	0.06	0.049	0.049	0.049	0.02	0.03	0.015
Image Projections per Revolution	1800	1800	1800	1800	1800	1800	1800	1800
Exposure time (ms)	285.58	285.58	285.58	285.58	285.58	285.58	285.58	285.58
Frames to Avg (frames per projection)	2	2	2	3	3	2	3	3
X-ray Source Voltage (kV)	222	222	222	223	223	222	222	220
X-ray Source Current (mA)	0.520	0.520	0.520	0.565	0.580	0.700	0.520	0.825
Source Filter Thickness (mm)	1	1	1	1	1	1	2	2
Source Filter Material	Brass	Brass	Brass	Brass	Brass	Brass	Brass	Brass
Image Matrix Size	2048 x 2048	2048 x 2048	2048 x 2048	1024 x 1024	1024 x 1024	2048 x 2048	2048 x 2048	2048 x 2048

The data sets of slice images were examined, processed, and analyzed by the NTSB using the VGStudioMax software package to convert the axial slice data into orthogonal slice images and a three-dimensional reconstructed image of the component. As part of the evaluation, some sections of the components were digitally removed or rendered transparent to allow closer observation of interior parts. In the images, the high density areas were shown as brighter shades of gray and lower density areas were shown as darker shades of gray. The pointers shown in some of the images denote specific areas of interest within that image.

The images of the components were examined for any signs of missing or damaged parts, contamination, or any other anomalies. Specific results (including example images) are presented in subsequent sections of this report.

2.0 Computed Tomography Results

The computed tomography (CT) results for the components are shown in figures 1 through 82. Review of the images indicated that, when the scans were conducted, the following items were noted:

Longitudinal trim actuator:

- there was a gap of 0.134 inches noted between the end of the actuator rod and the actuator spring cartridge end fixture;
- there were 2.724 inches of actuator screw thread between the actuator screw ball and the actuator screw base;
- there were no indications of failure within the actuator motor bearings or output gear train;
- there were indications of small clearances between the actuator motor wires and the motor ground terminal components and between the wires themselves;
- there were no indications of short circuits or other wiring damage within the actuator motor or circuit board wiring;

Lateral trim actuator:

- there was a gap of 0.219 inches noted between the end of the actuator spring cartridge end fixture and the actuator rod end fixture;
- there were 0.517 inches of actuator screw thread between the actuator screw ball and the actuator screw base;
- there were no indications of failure within the actuator motor bearings or output gear train;
- there were no indications of short circuits or other wiring damage within the actuator motor or circuit board wiring;

Cyclic grip and trim switch:

- there was a crack noted in the trim switch insert;

- there were multiple indications of high density particles within the trim switch;
- there were no indications of a material buildup that would have caused a short circuit within the trim switch.

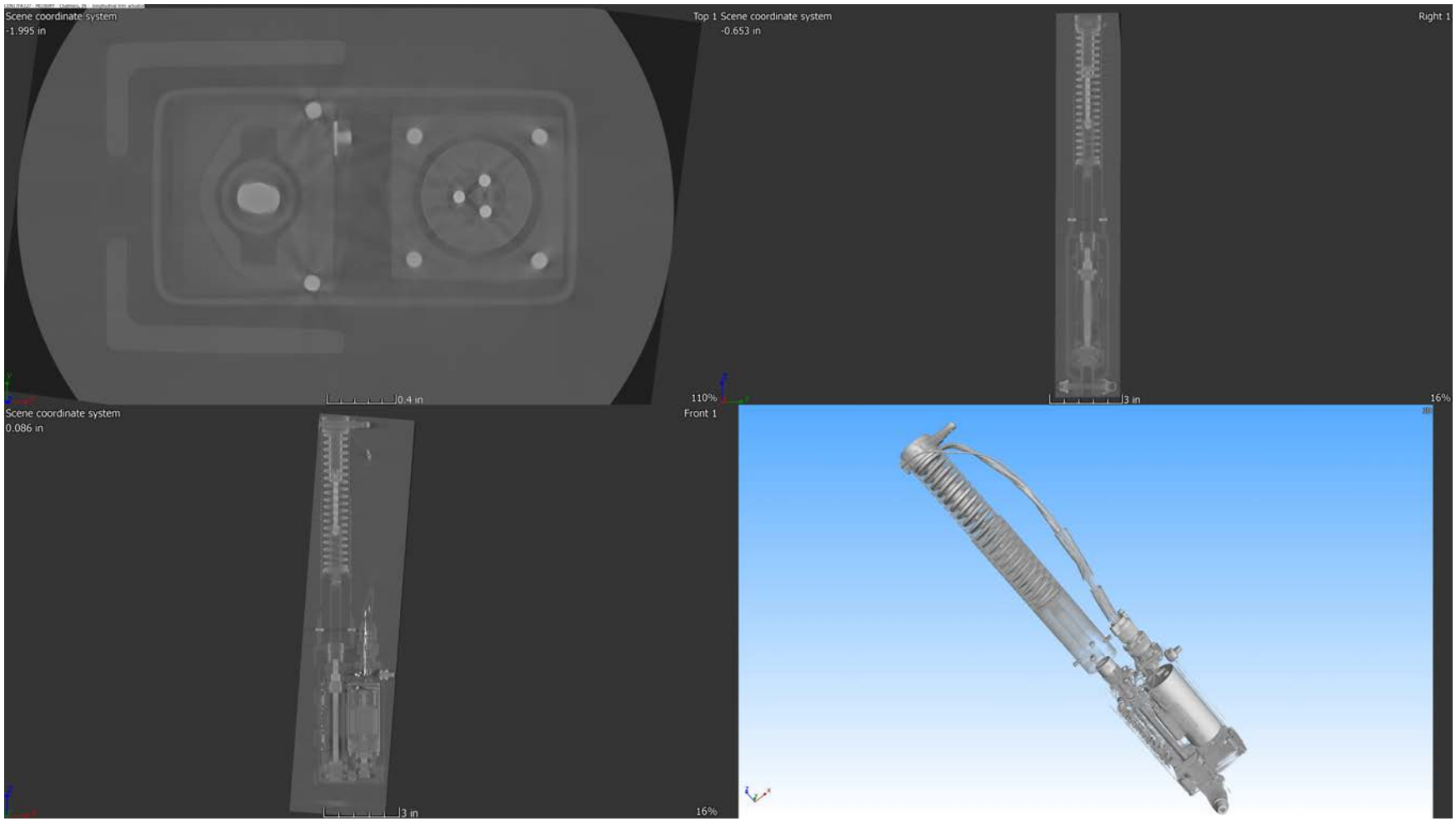

Figure 1
Longitudinal trim actuator – overview

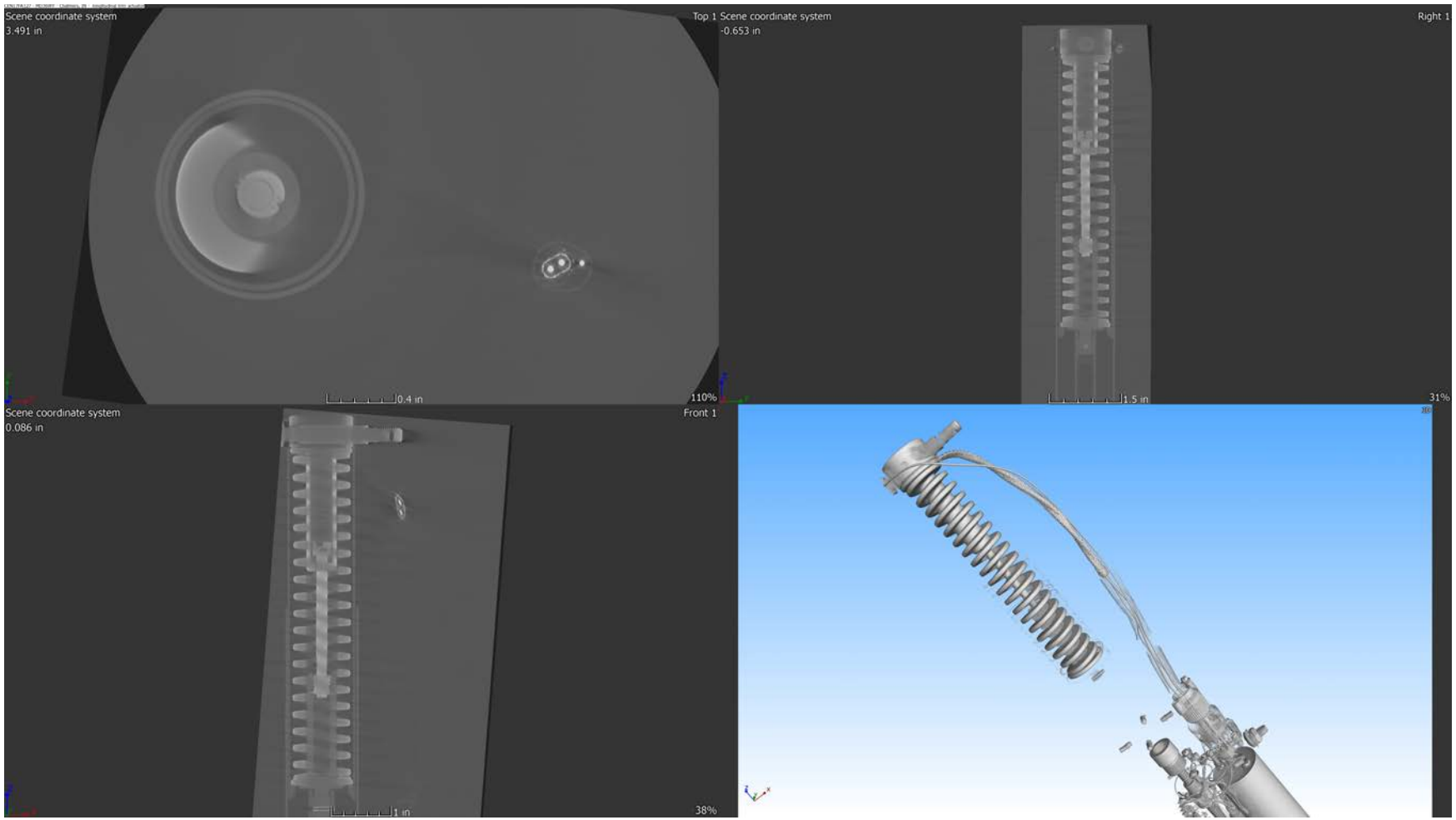

Figure 2
Longitudinal trim actuator – spring

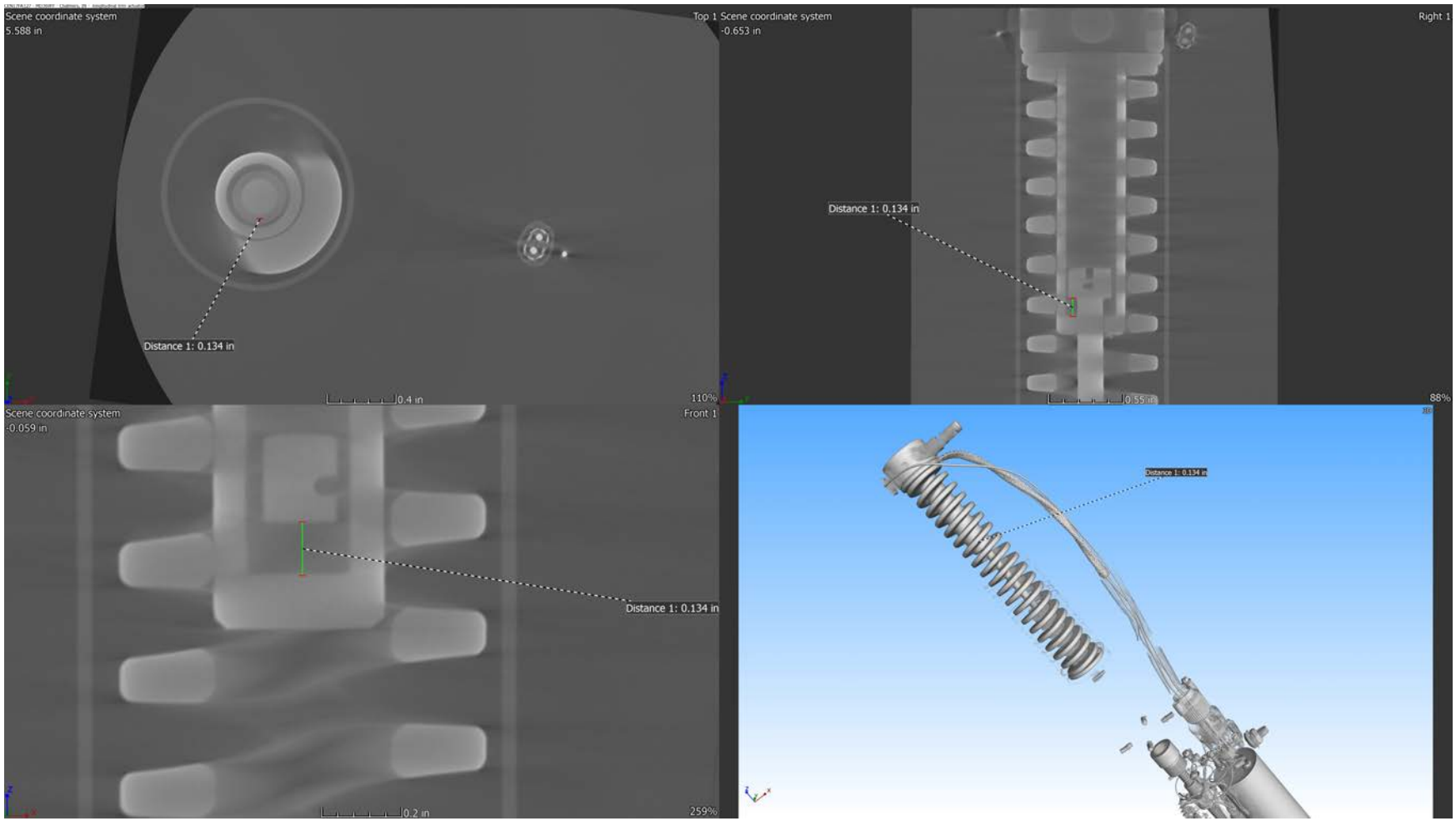

Figure 3
Longitudinal trim actuator – gap

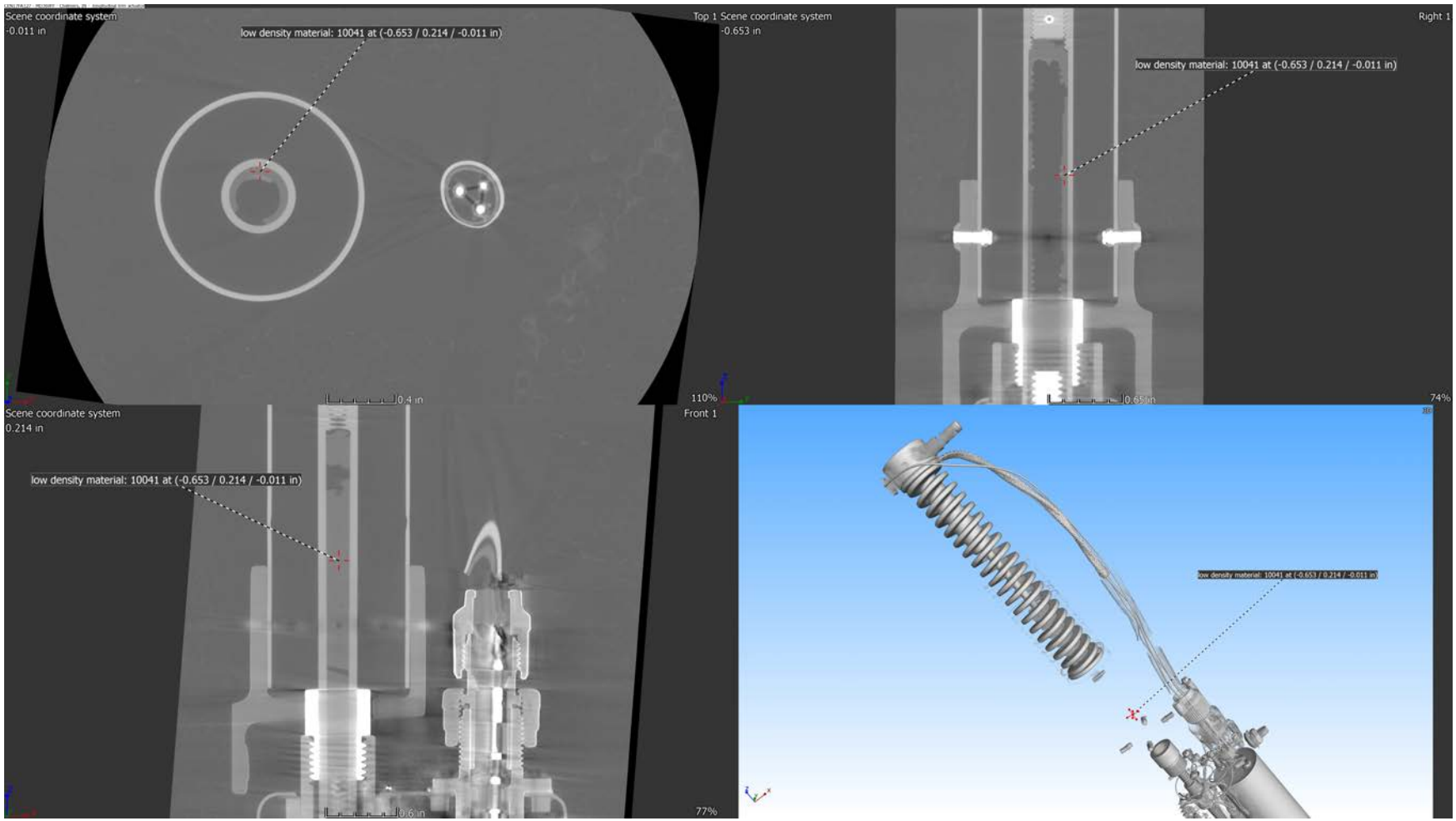

Figure 4
Longitudinal trim actuator – low density material

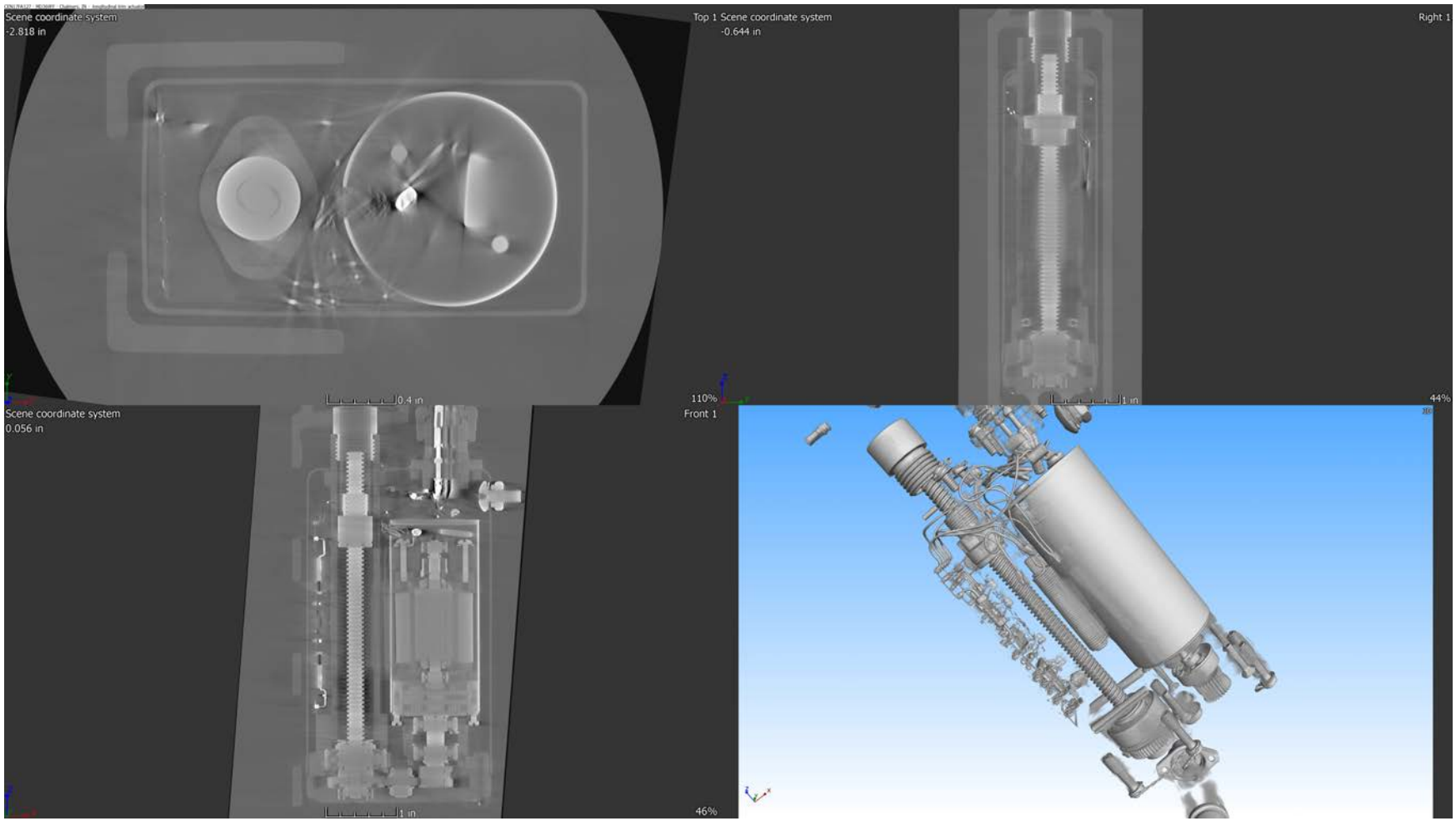

Figure 5
Longitudinal trim actuator – screw

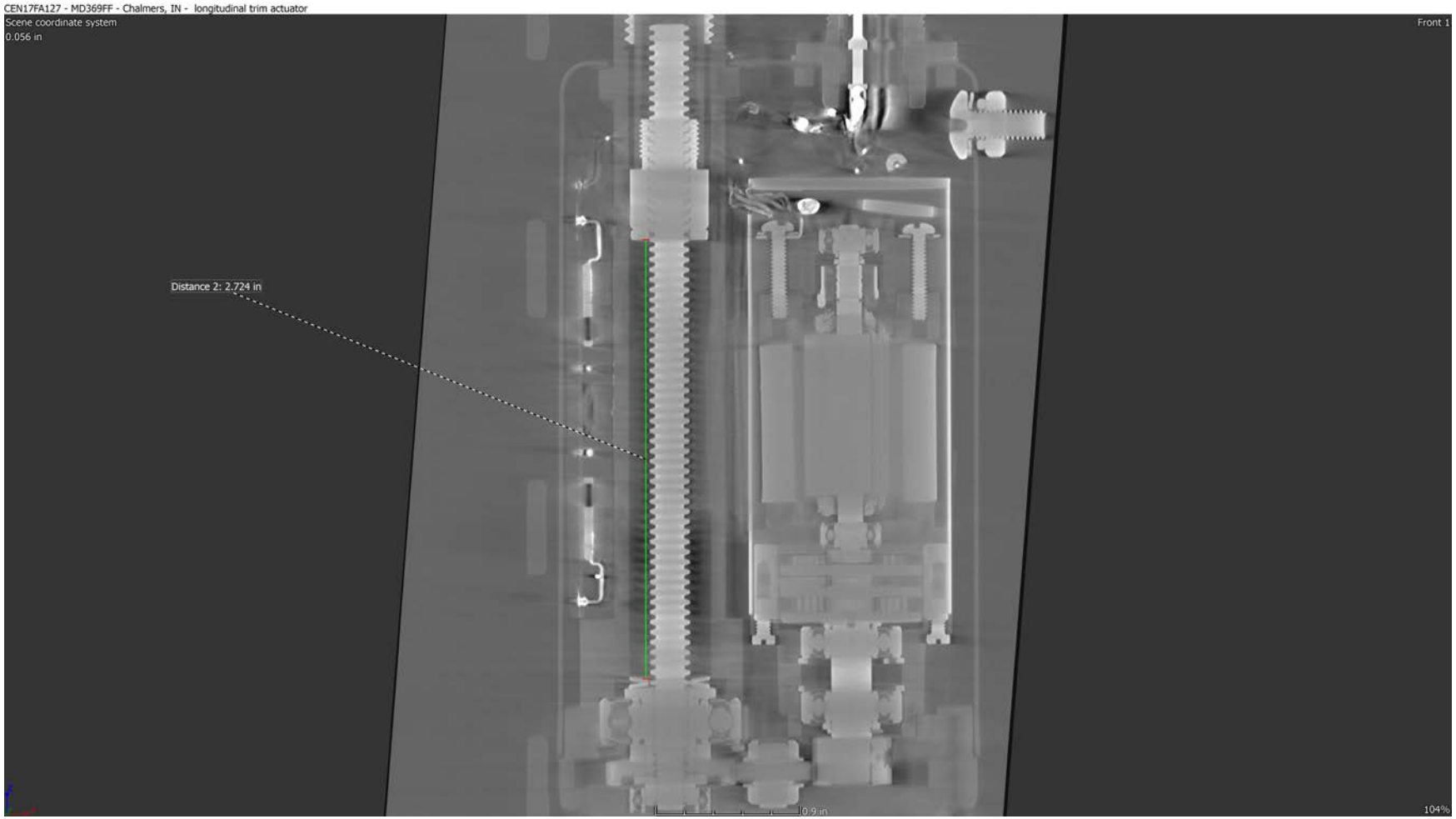

Figure 6
Longitudinal trim actuator – screw dimension

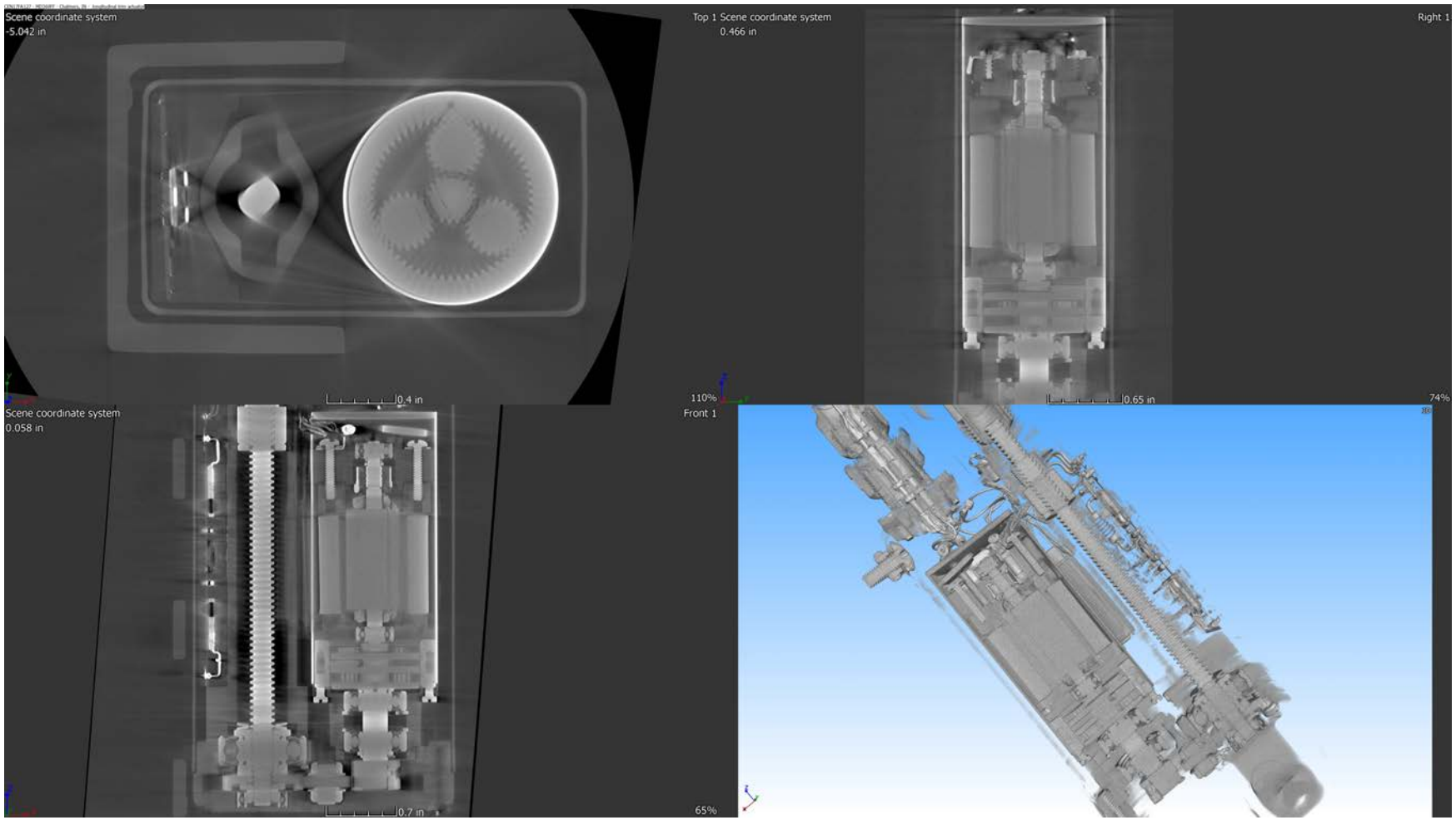

Figure 7
Longitudinal trim actuator – motor and gear train

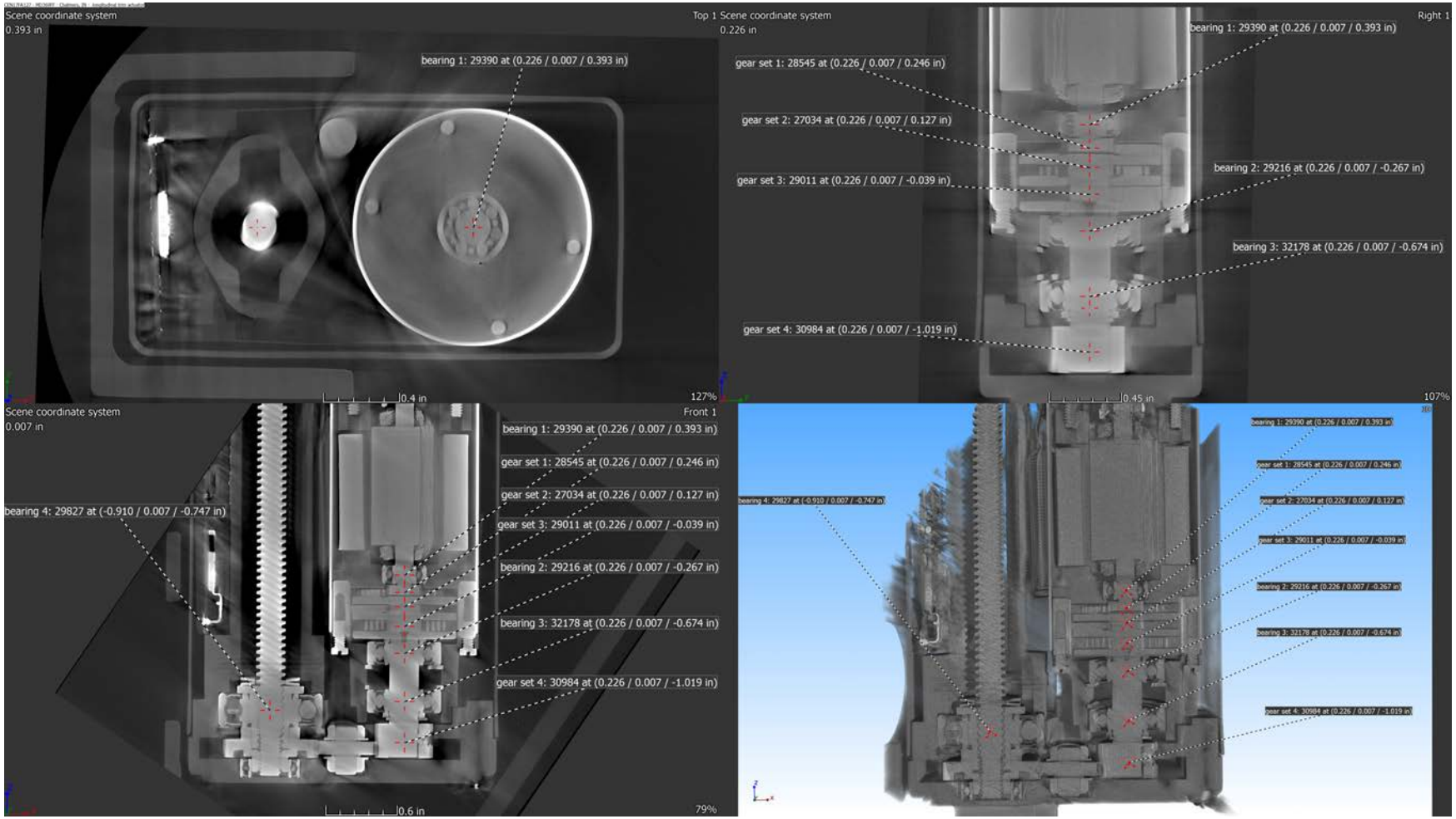

Figure 8
Longitudinal trim actuator – gear set and bearing overview

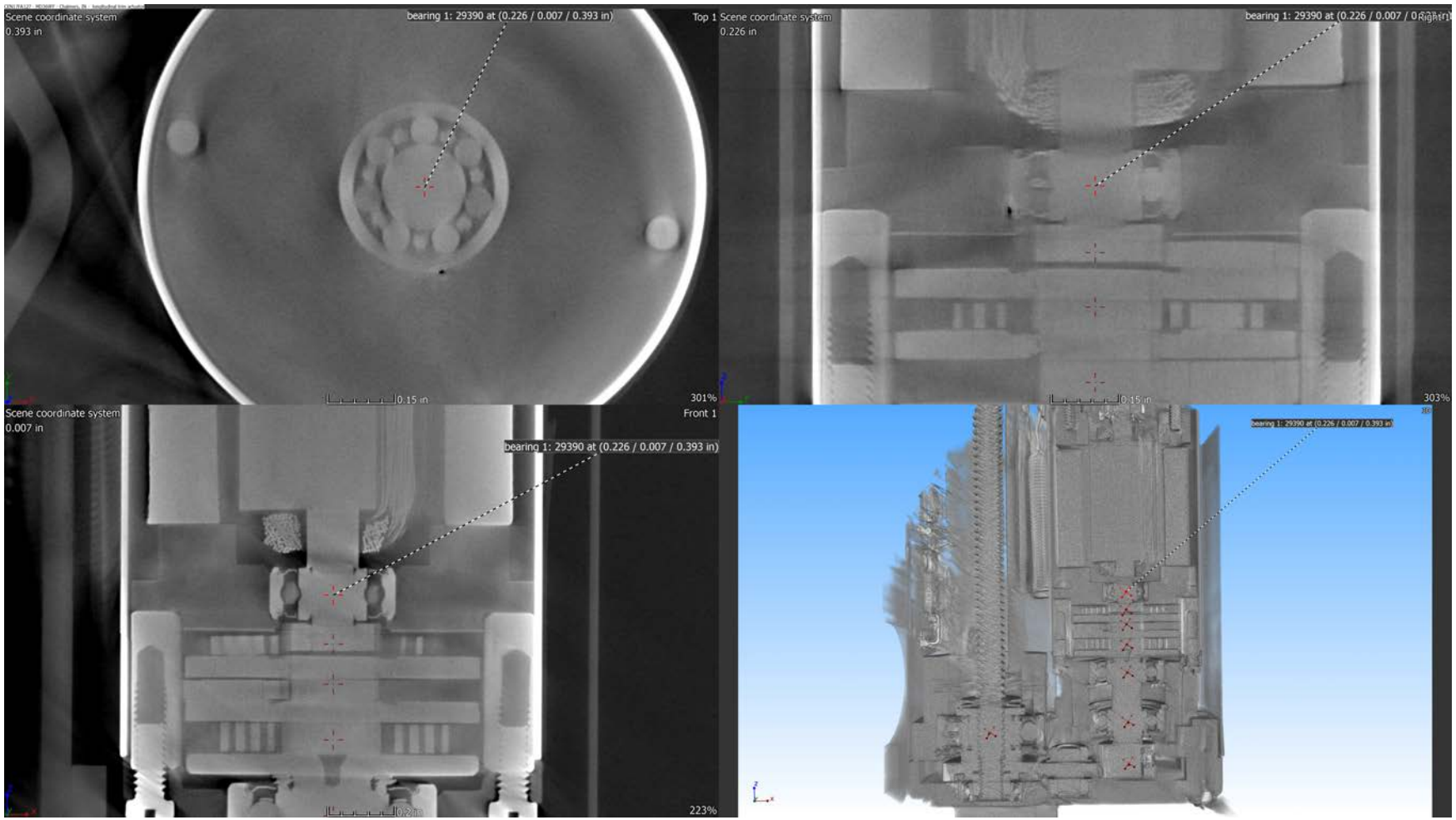

Figure 9
Longitudinal trim actuator – bearing 1

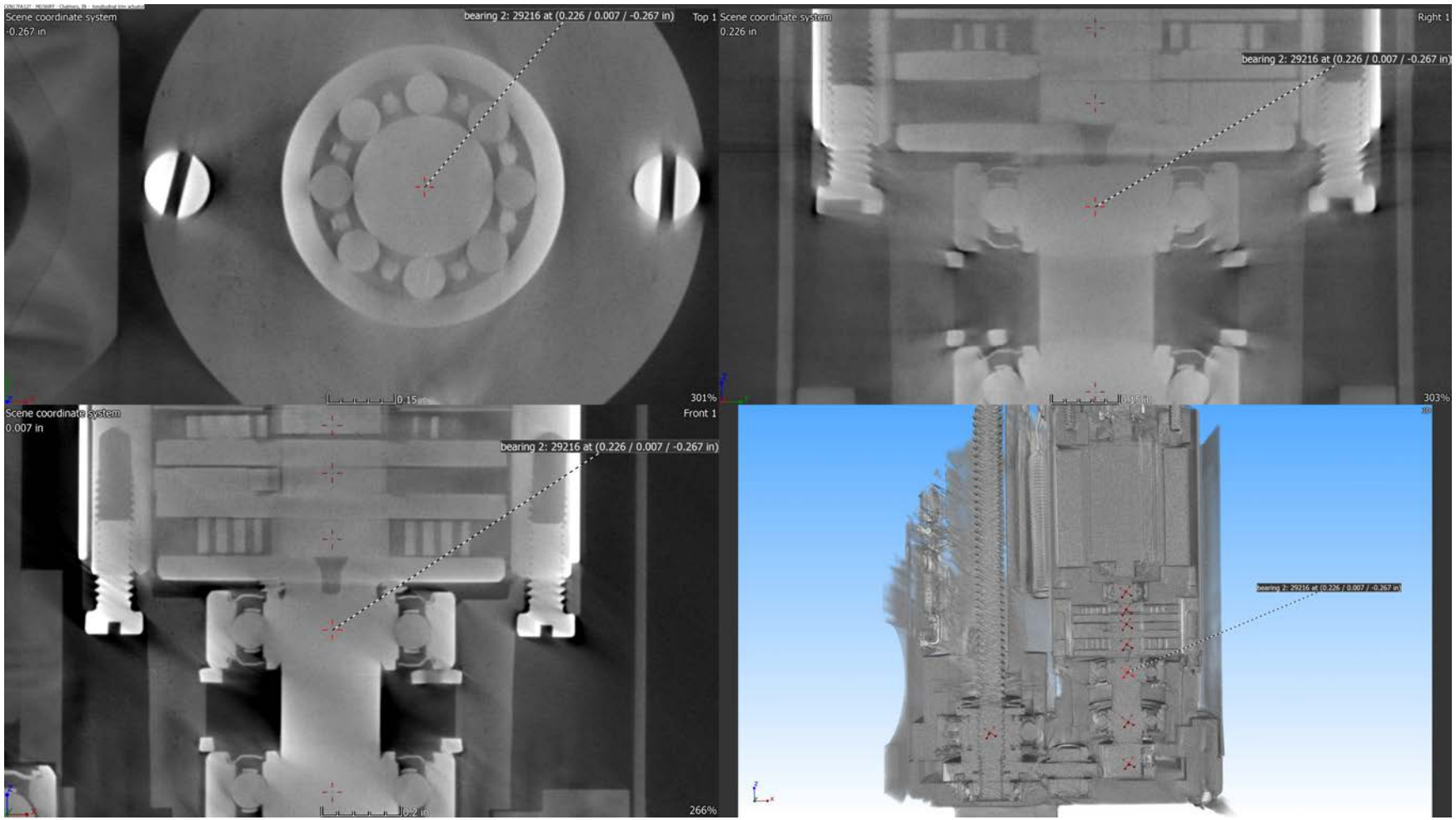

Figure 10
Longitudinal trim actuator – bearing 2

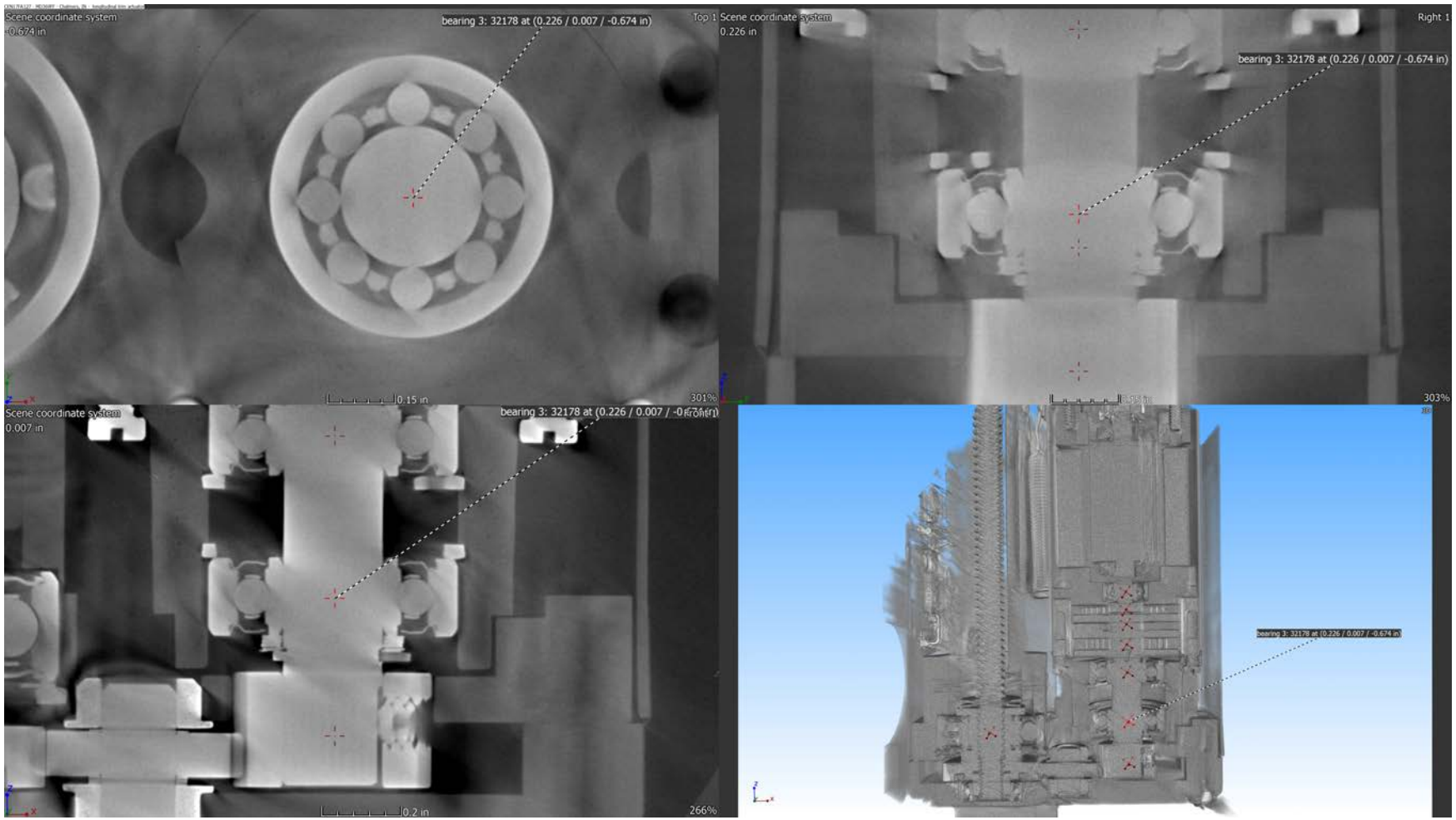

Figure 11
Longitudinal trim actuator – bearing 3

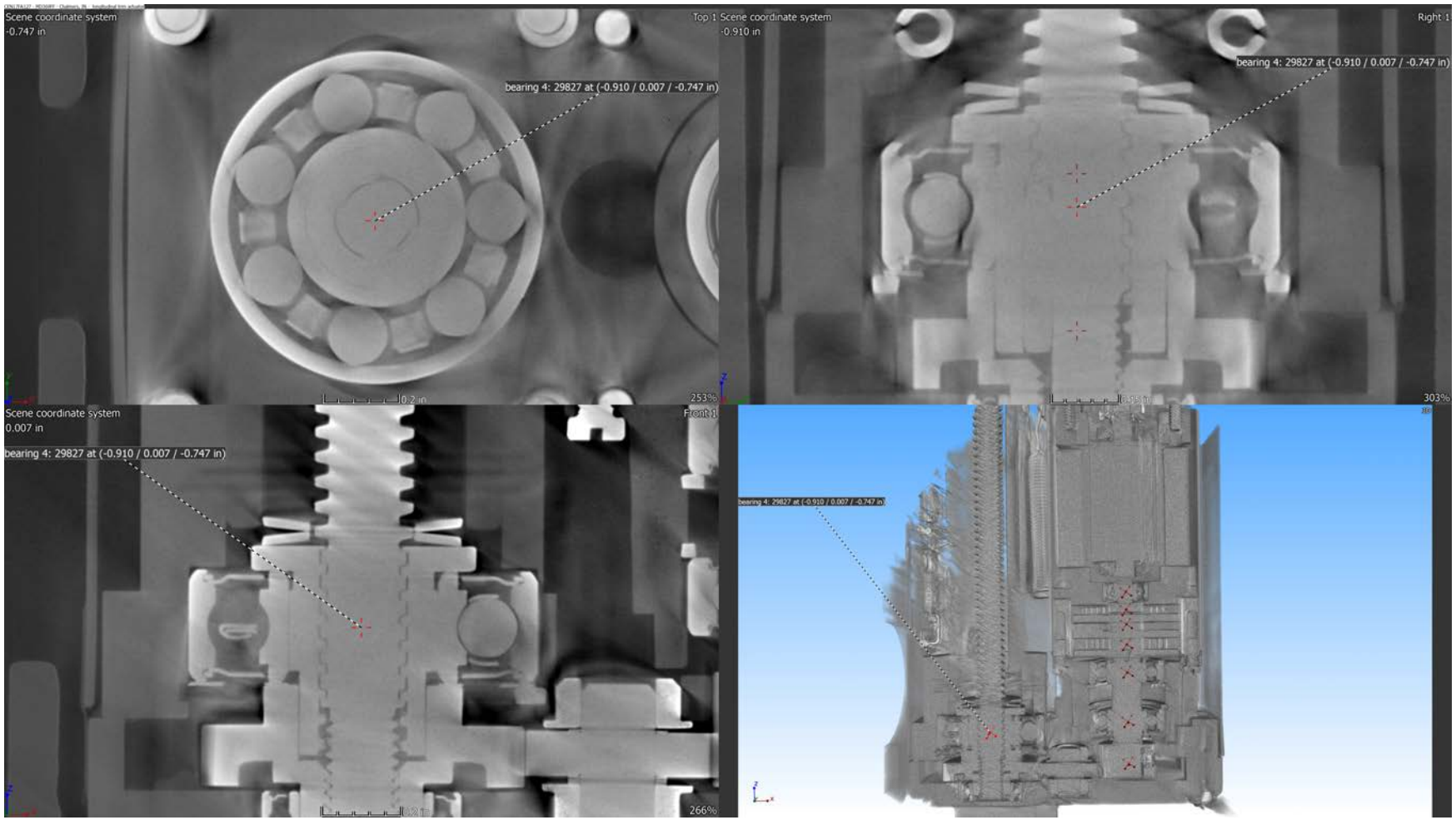

Figure 12
Longitudinal trim actuator – bearing 4

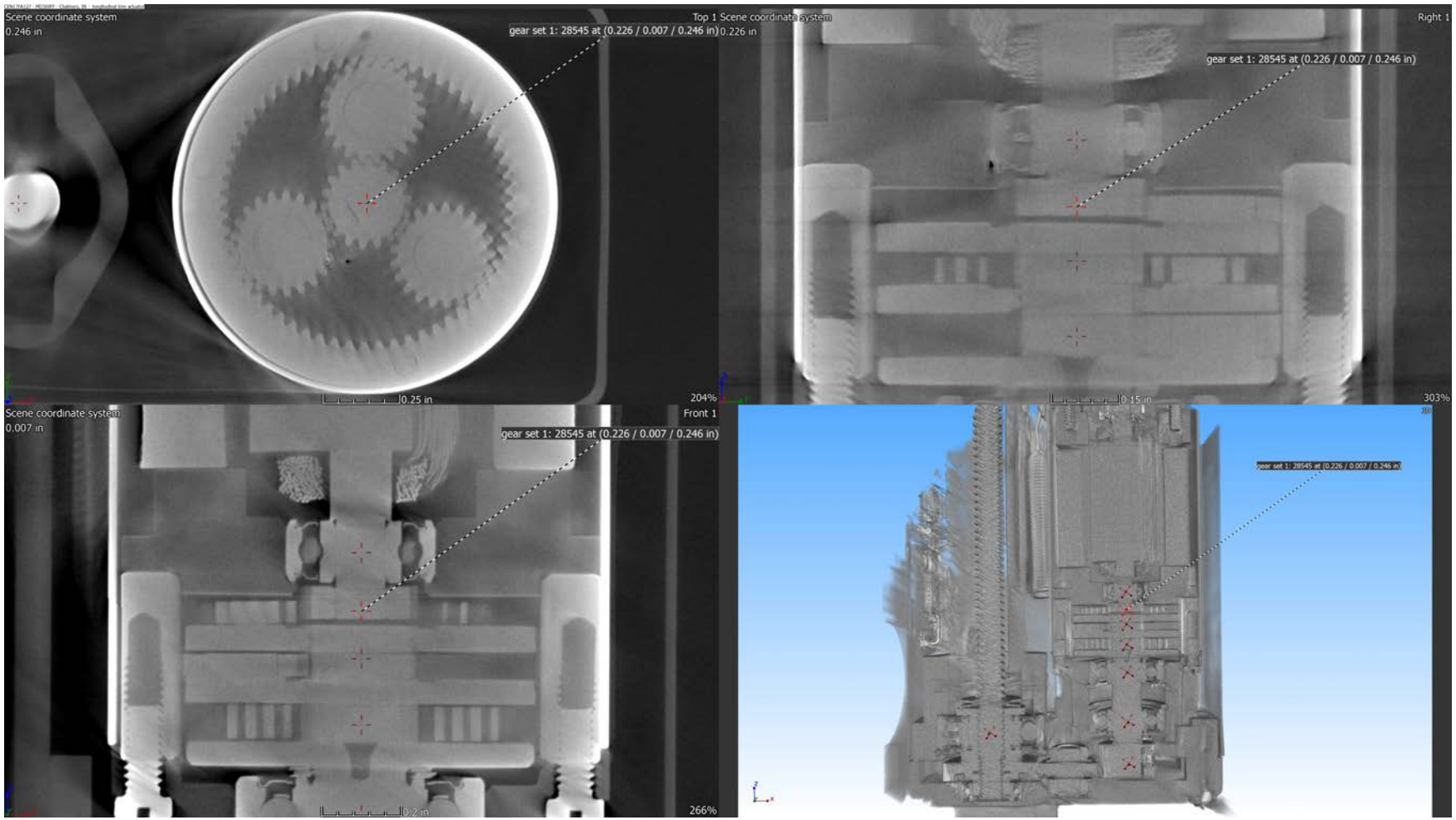

Figure 13
Longitudinal trim actuator – gear set 1

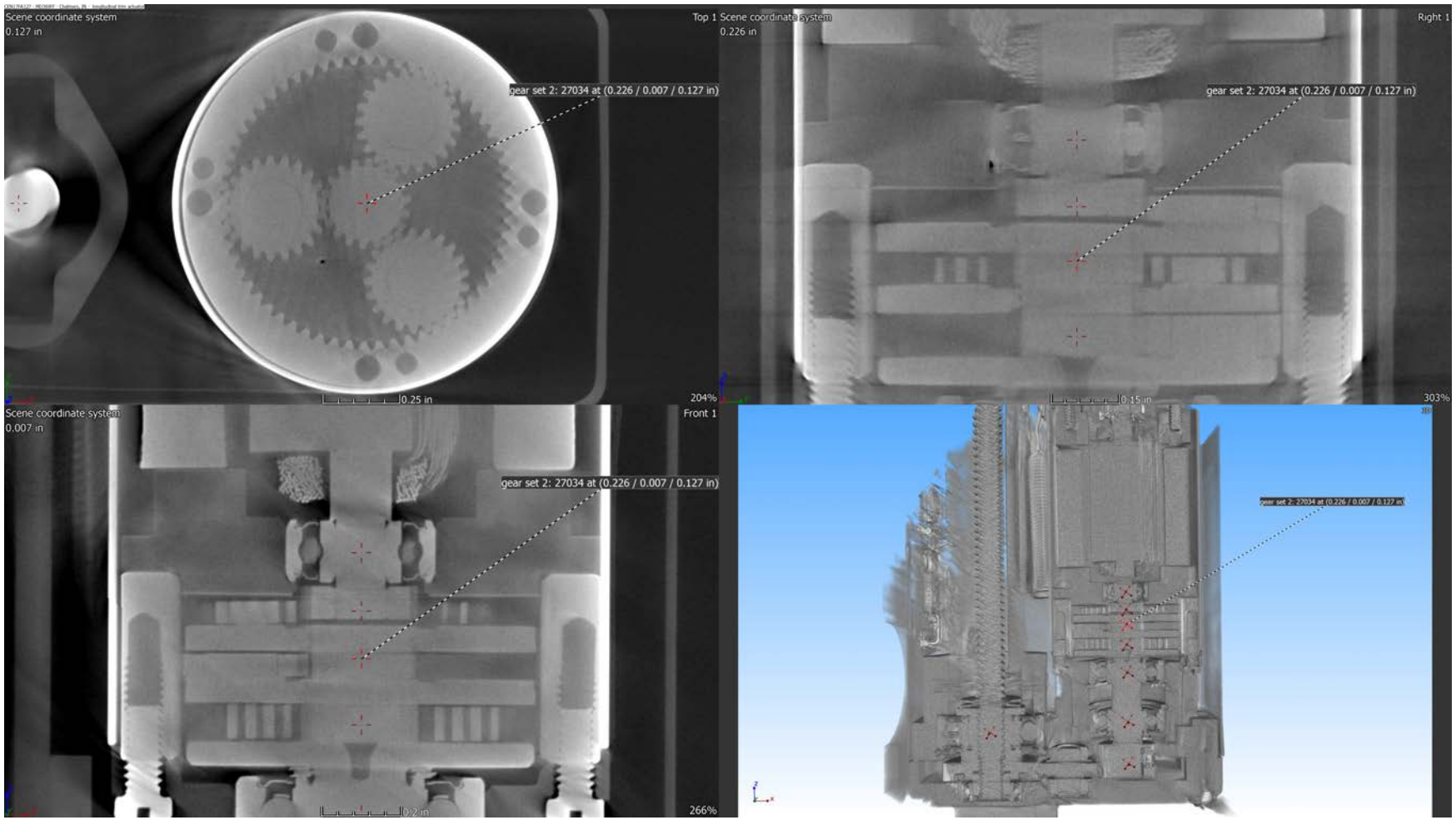

Figure 14
Longitudinal trim actuator – gear set 2

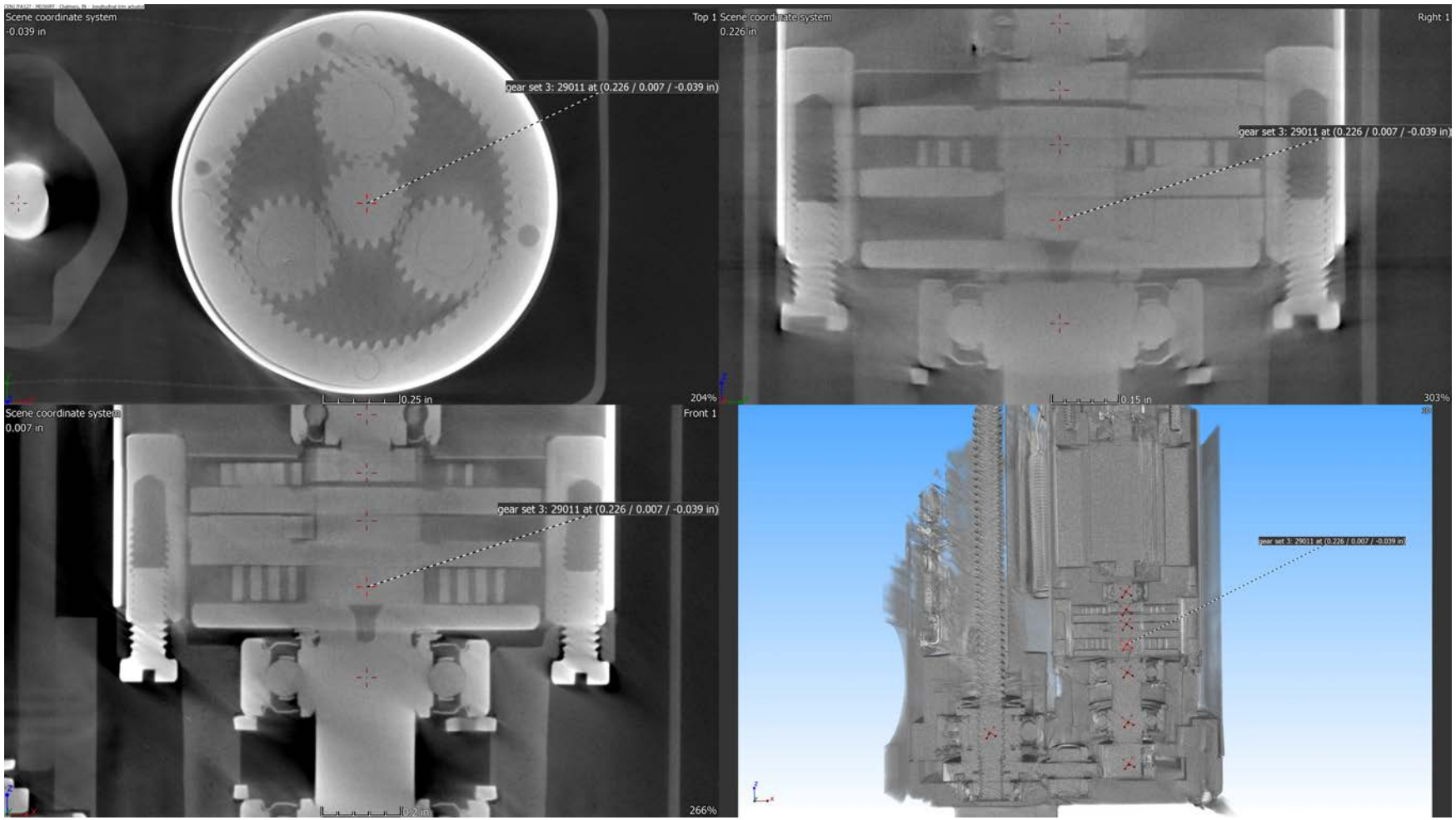

Figure 15
Longitudinal trim actuator – gear set 3

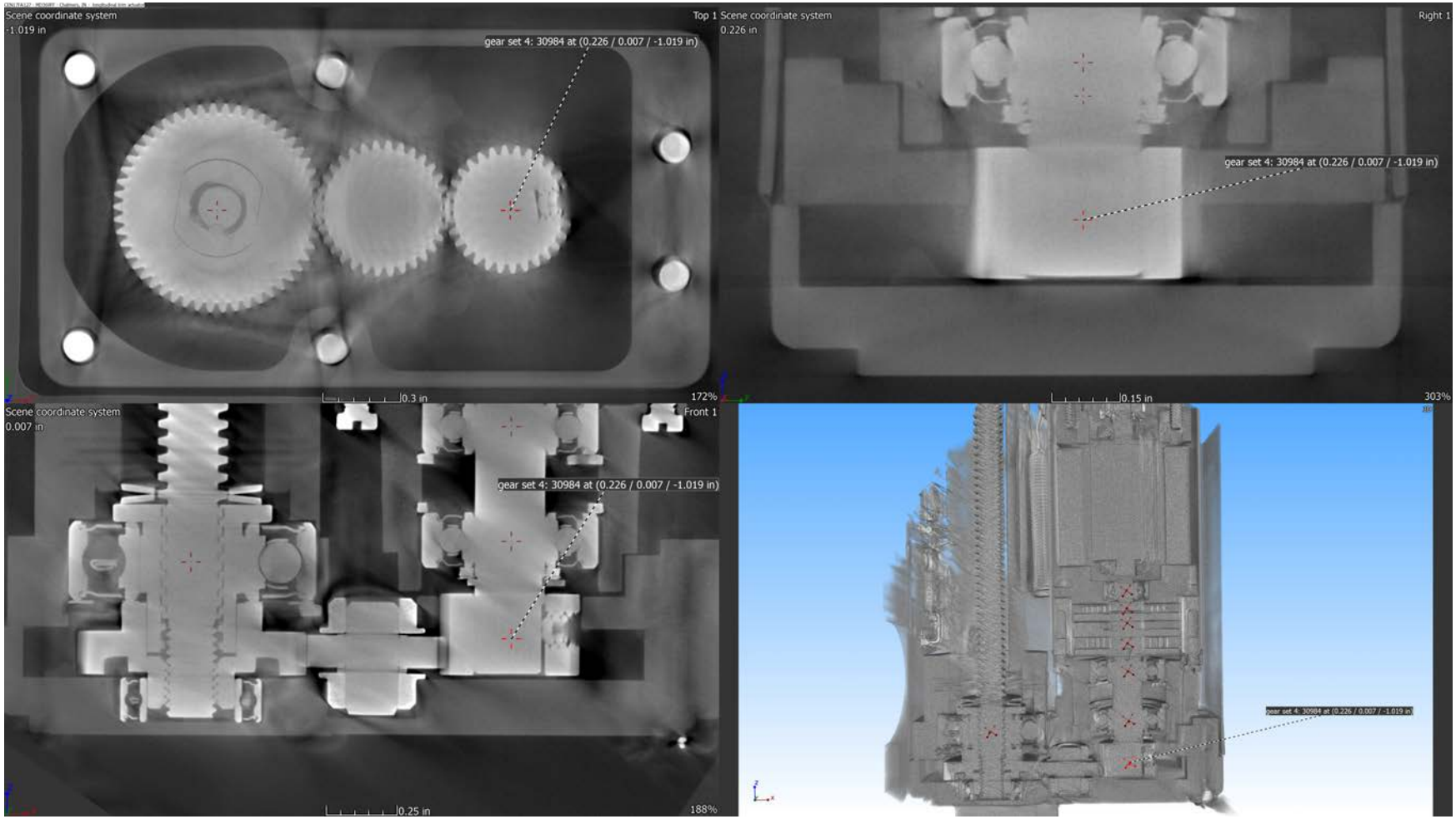

Figure 16
Longitudinal trim actuator – gear set 4

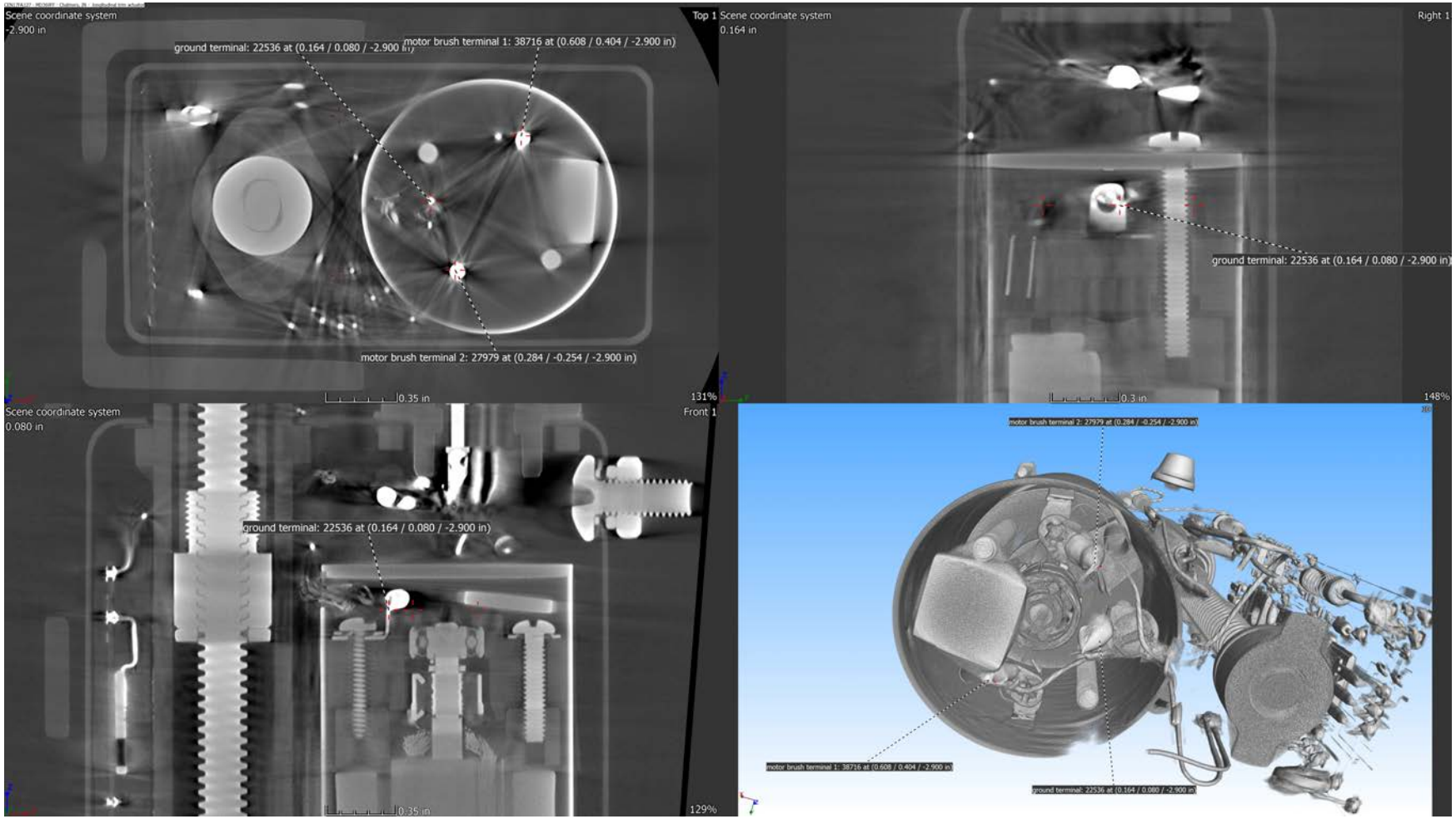

Figure 17
Longitudinal trim actuator – motor terminals

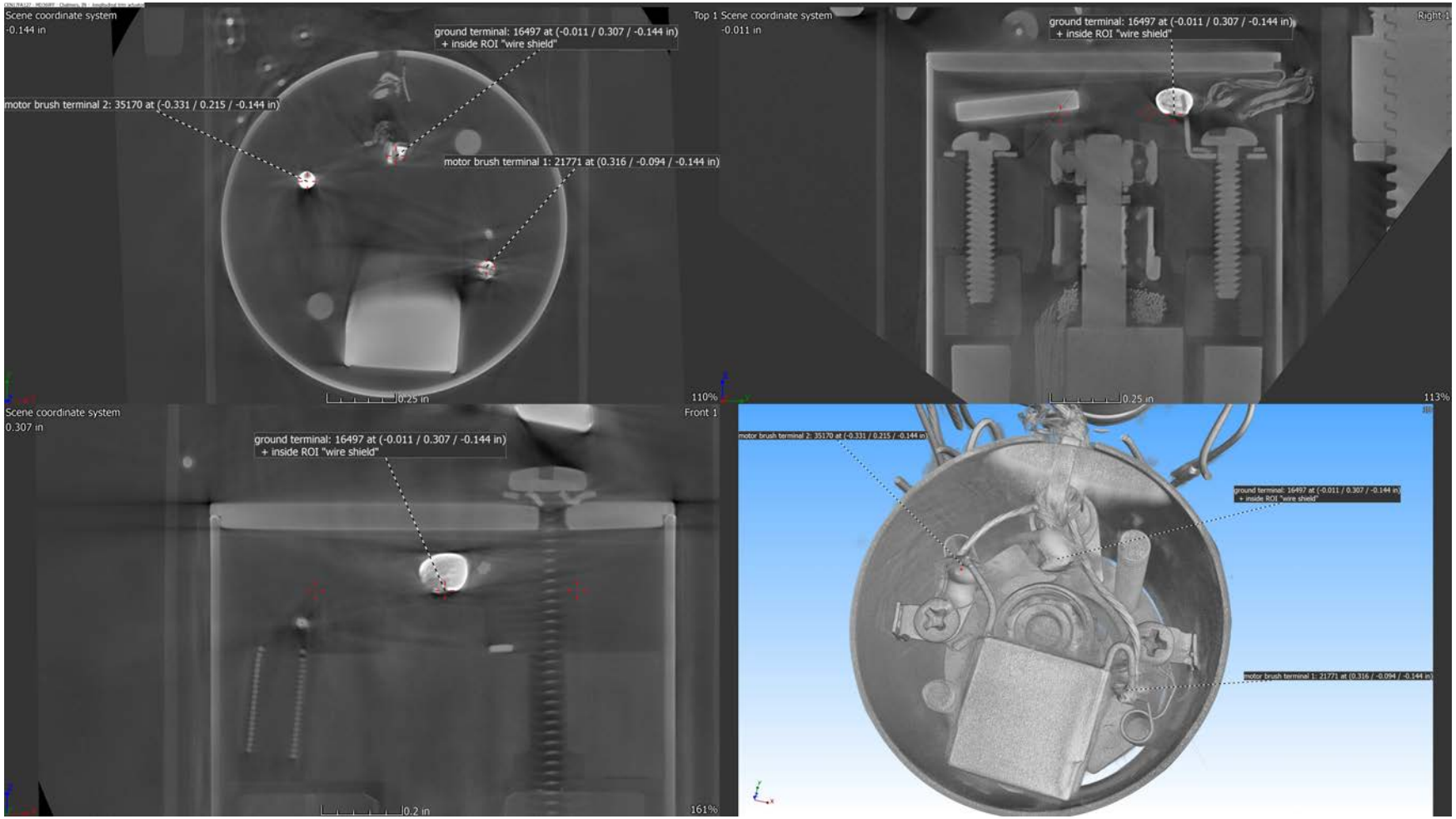

Figure 18
Longitudinal trim actuator – ground terminal

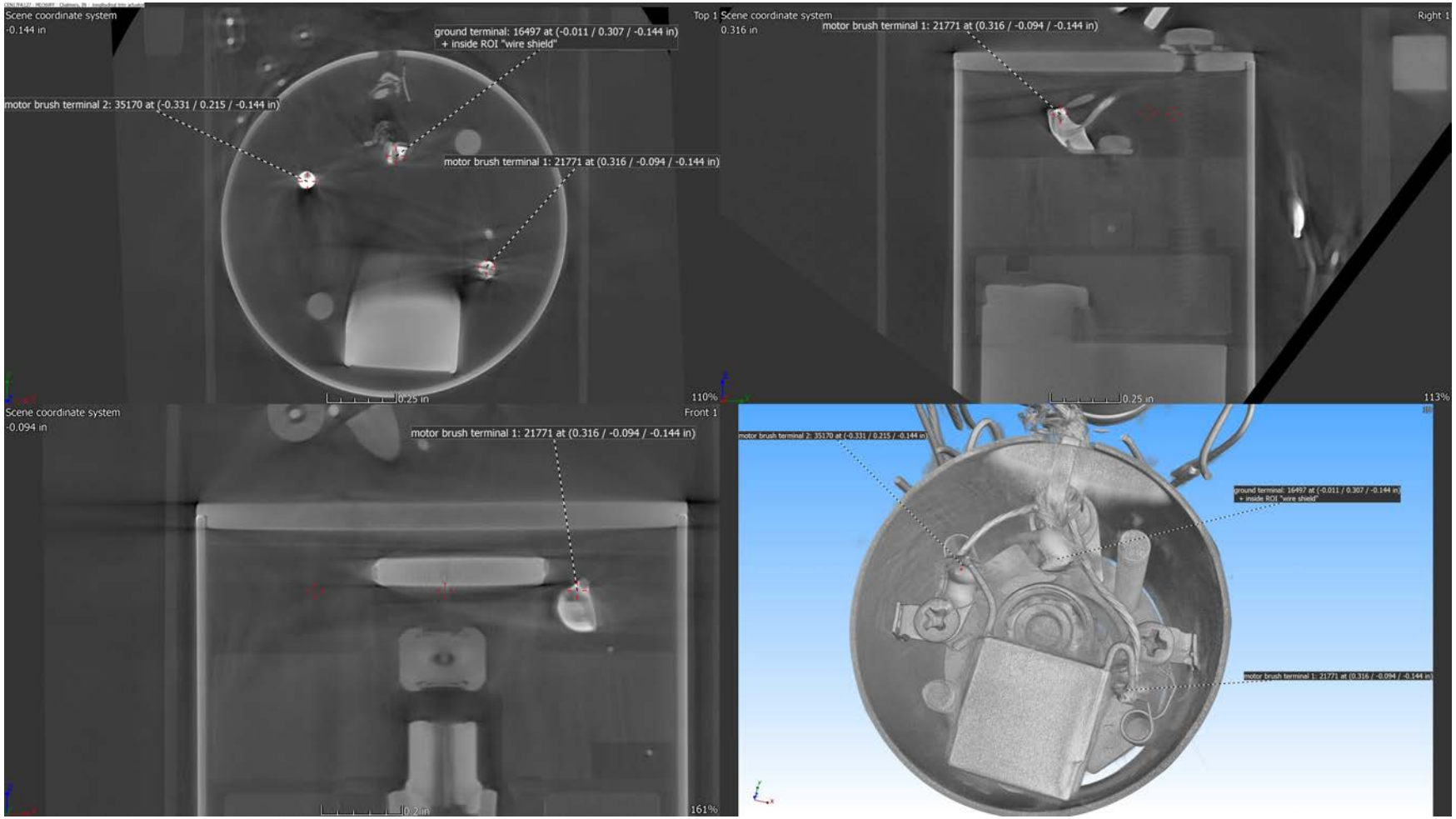

Figure 19
Longitudinal trim actuator – motor brush terminal 1

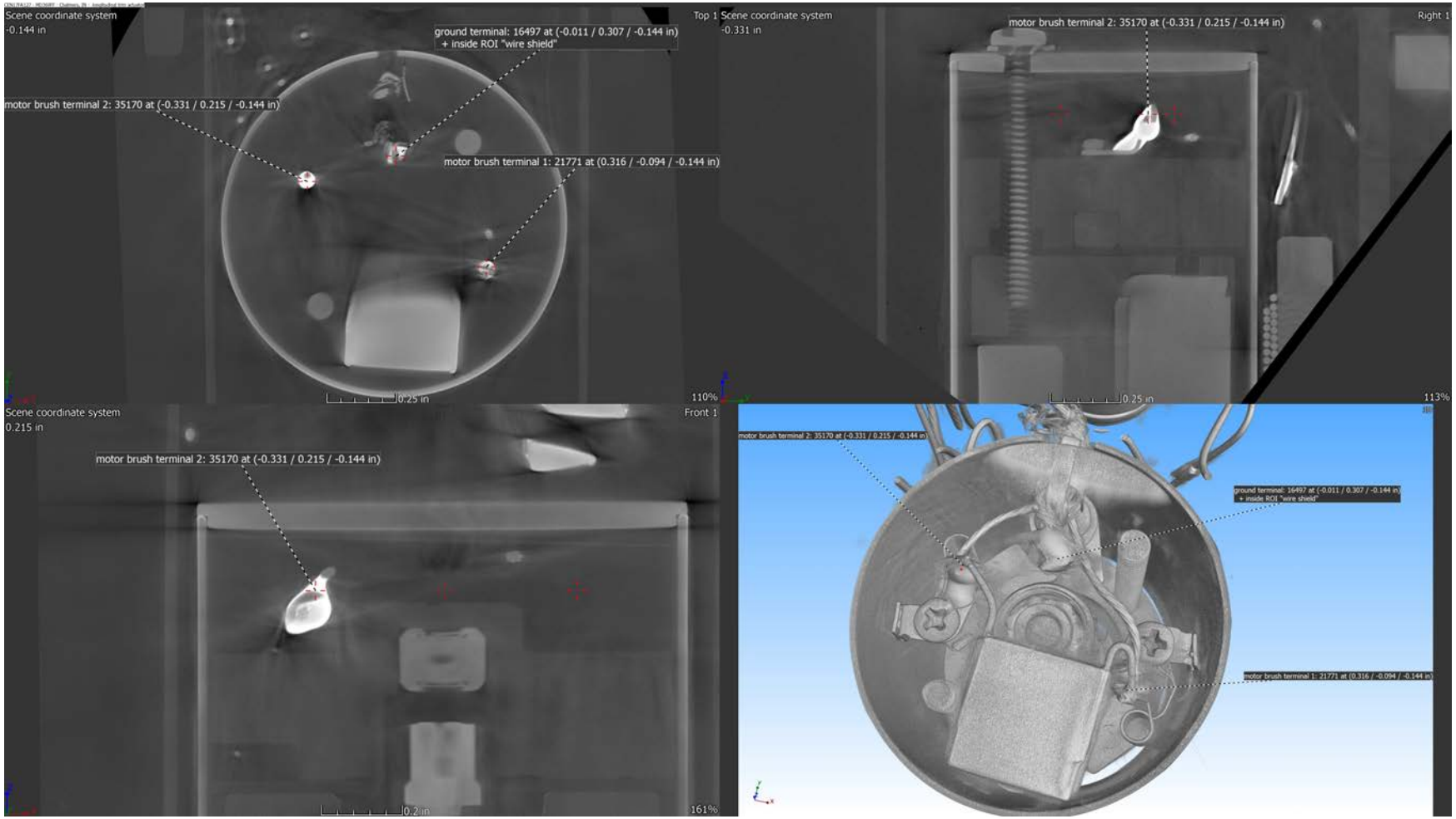

Figure 20
Longitudinal trim actuator – motor brush terminal 2

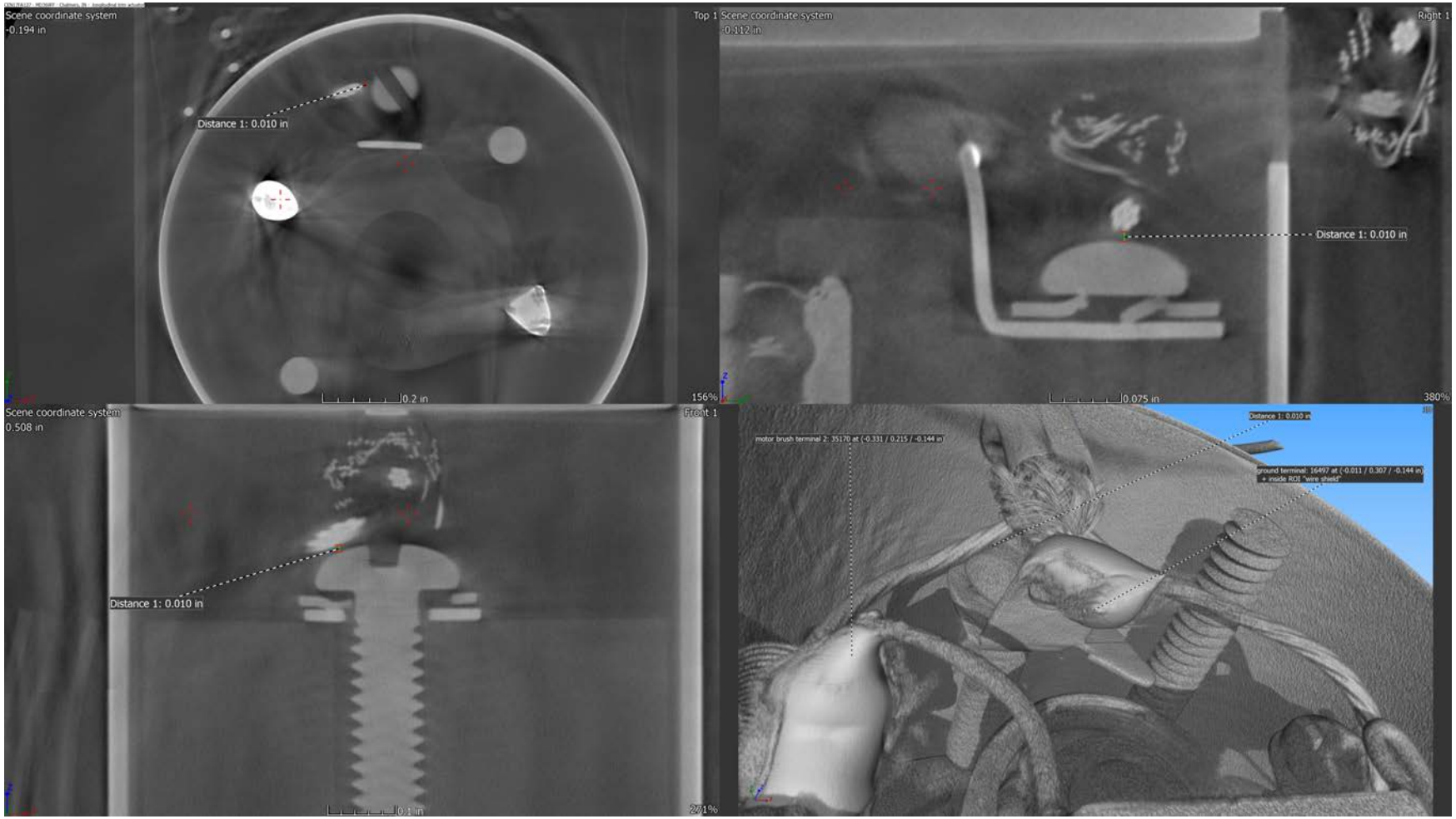

Figure 21
Longitudinal trim actuator – wire to ground terminal screw clearance

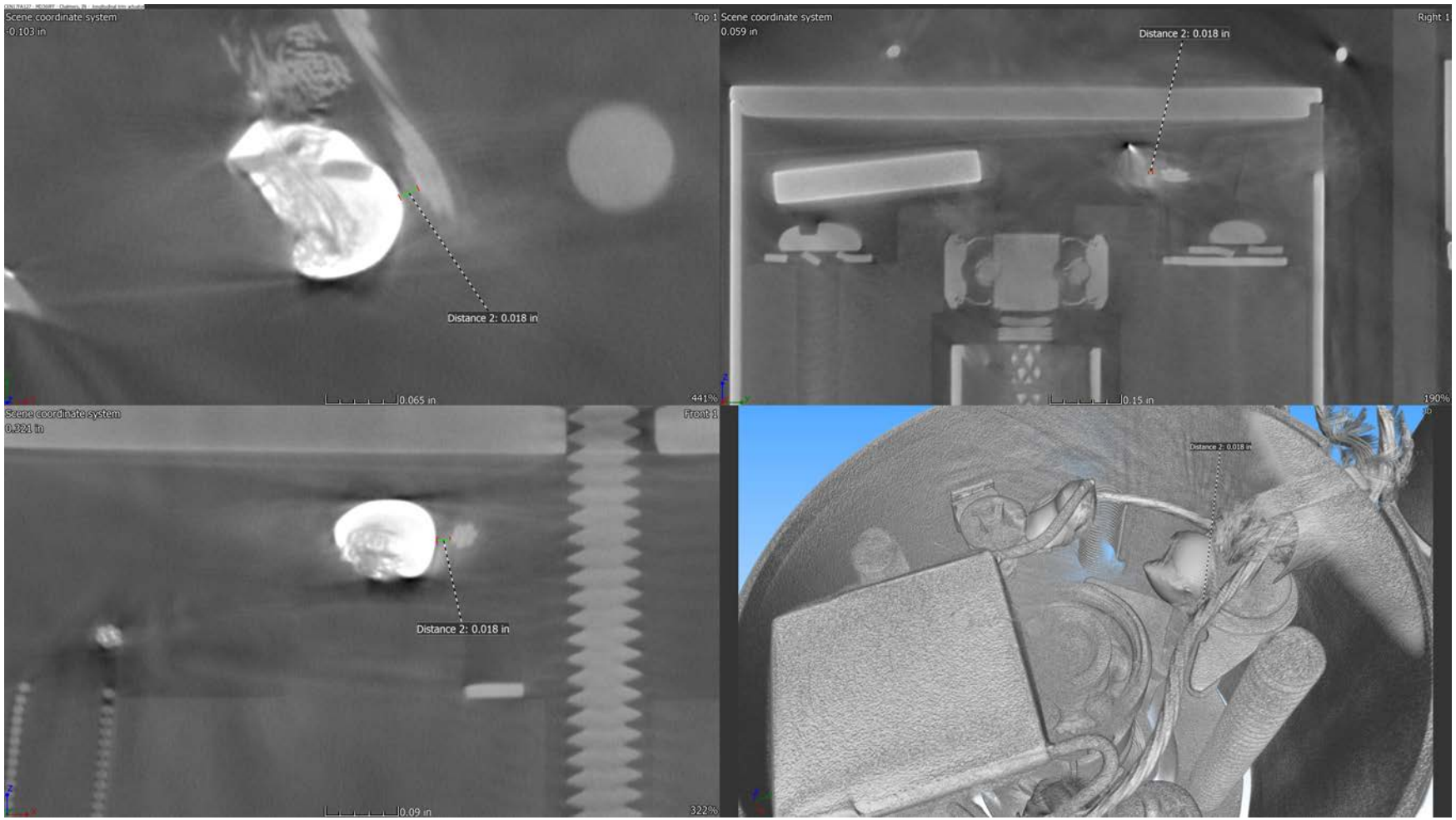

Figure 22
Longitudinal trim actuator – wire 1 to ground terminal clearance

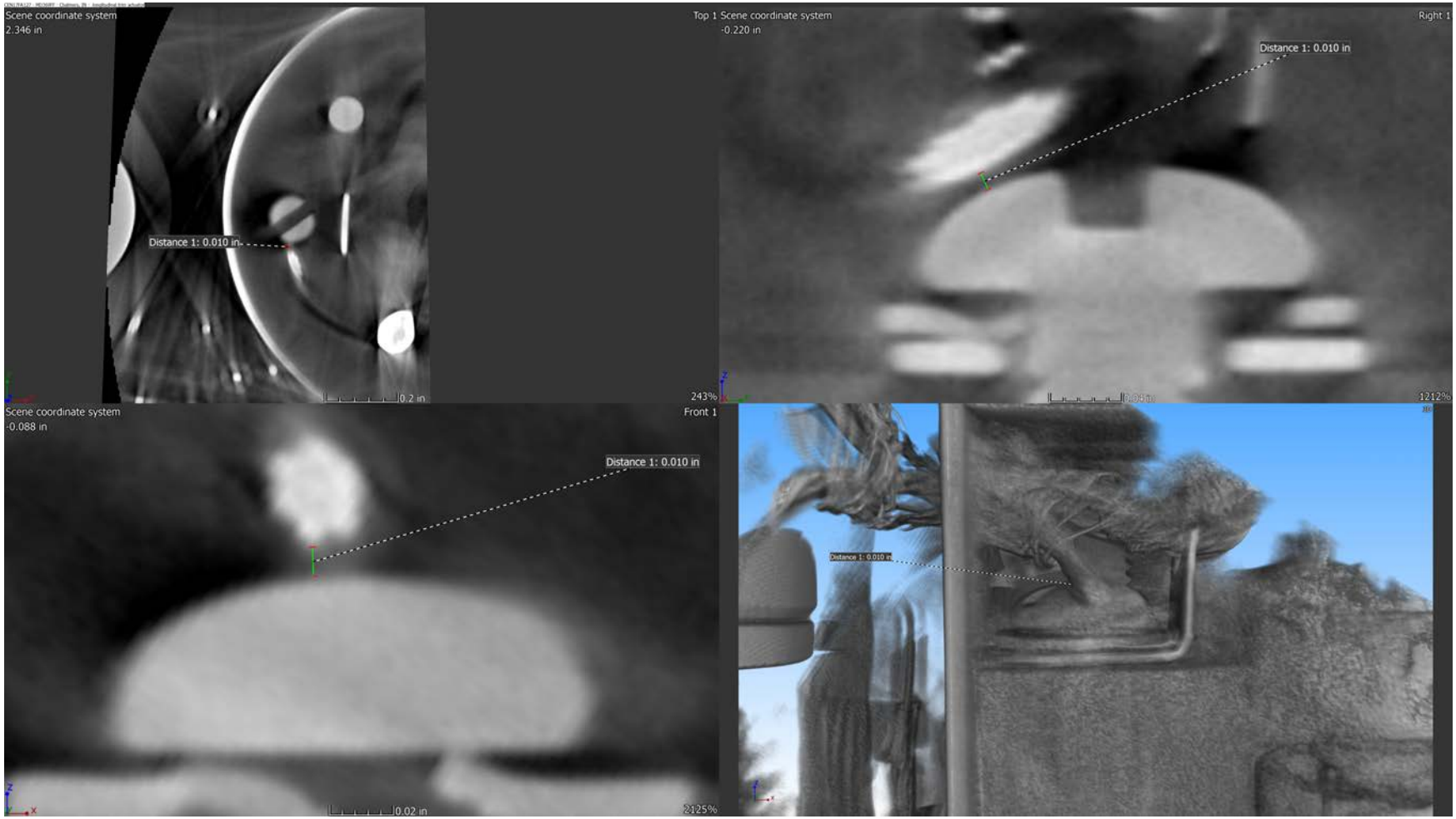

Figure 23
Longitudinal trim actuator – wire 2 to ground terminal screw clearance

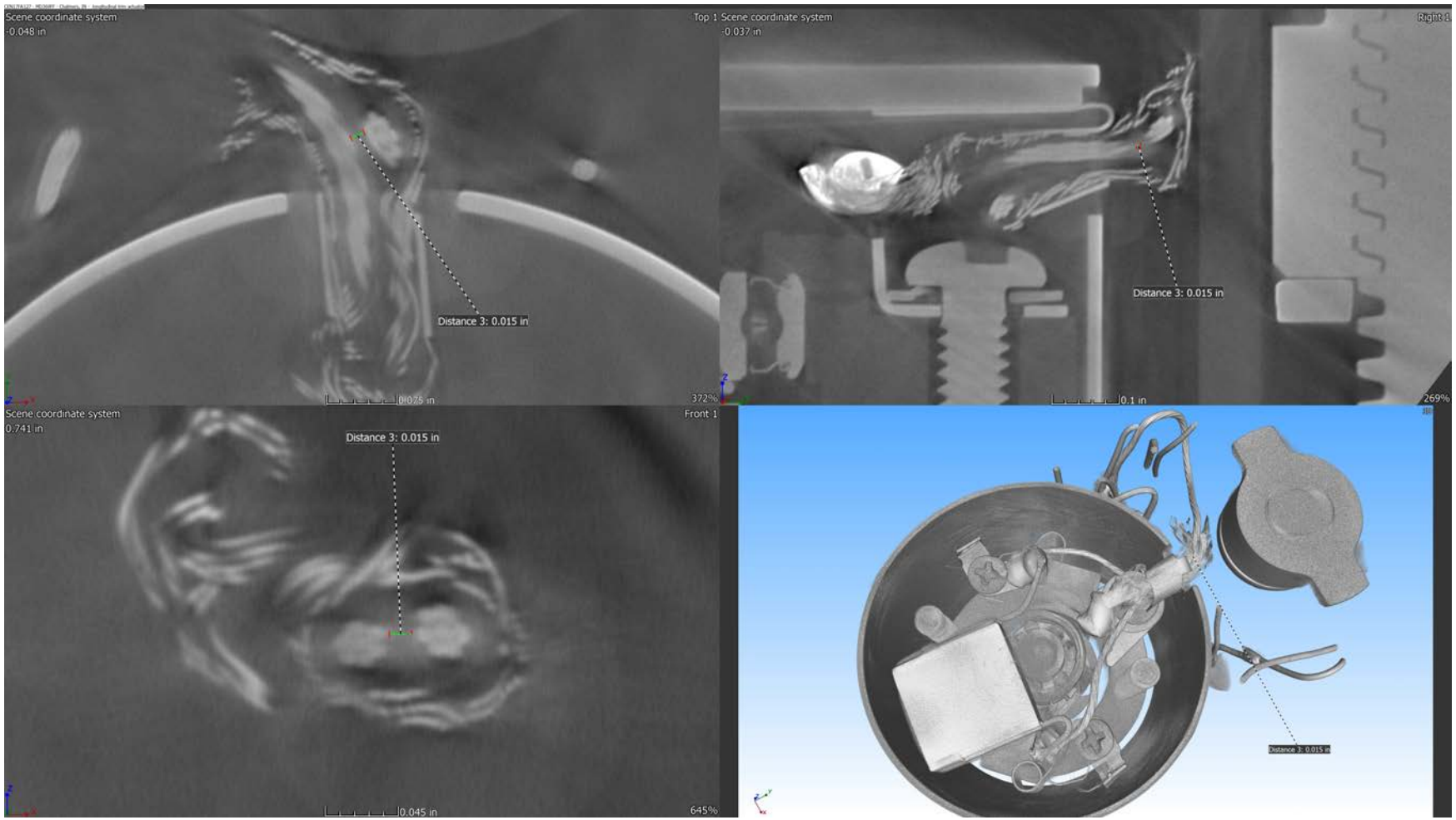

Figure 24
Longitudinal trim actuator – wire 1 to wire 2 clearance

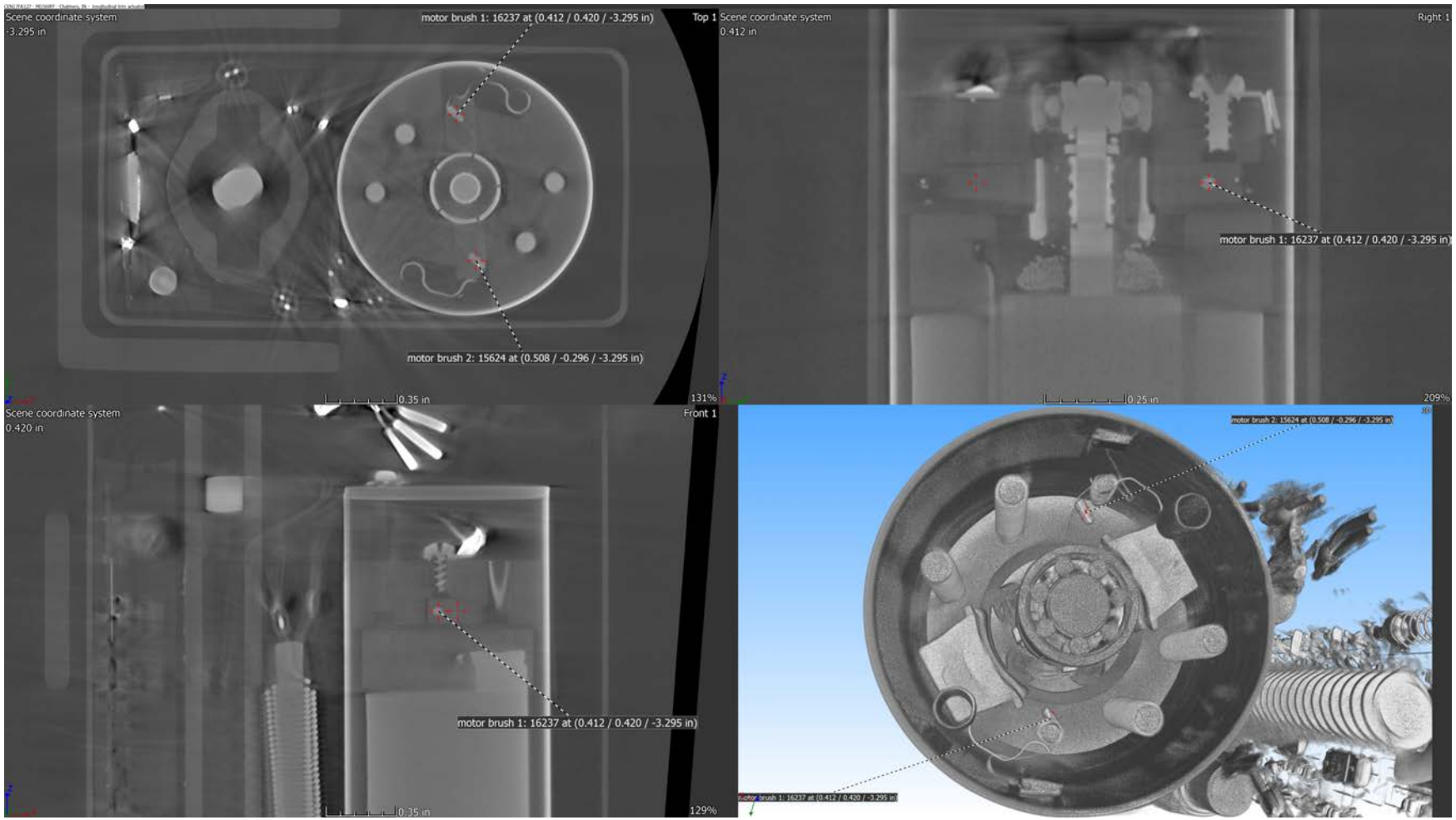

Figure 25
Longitudinal trim actuator – motor brush 1

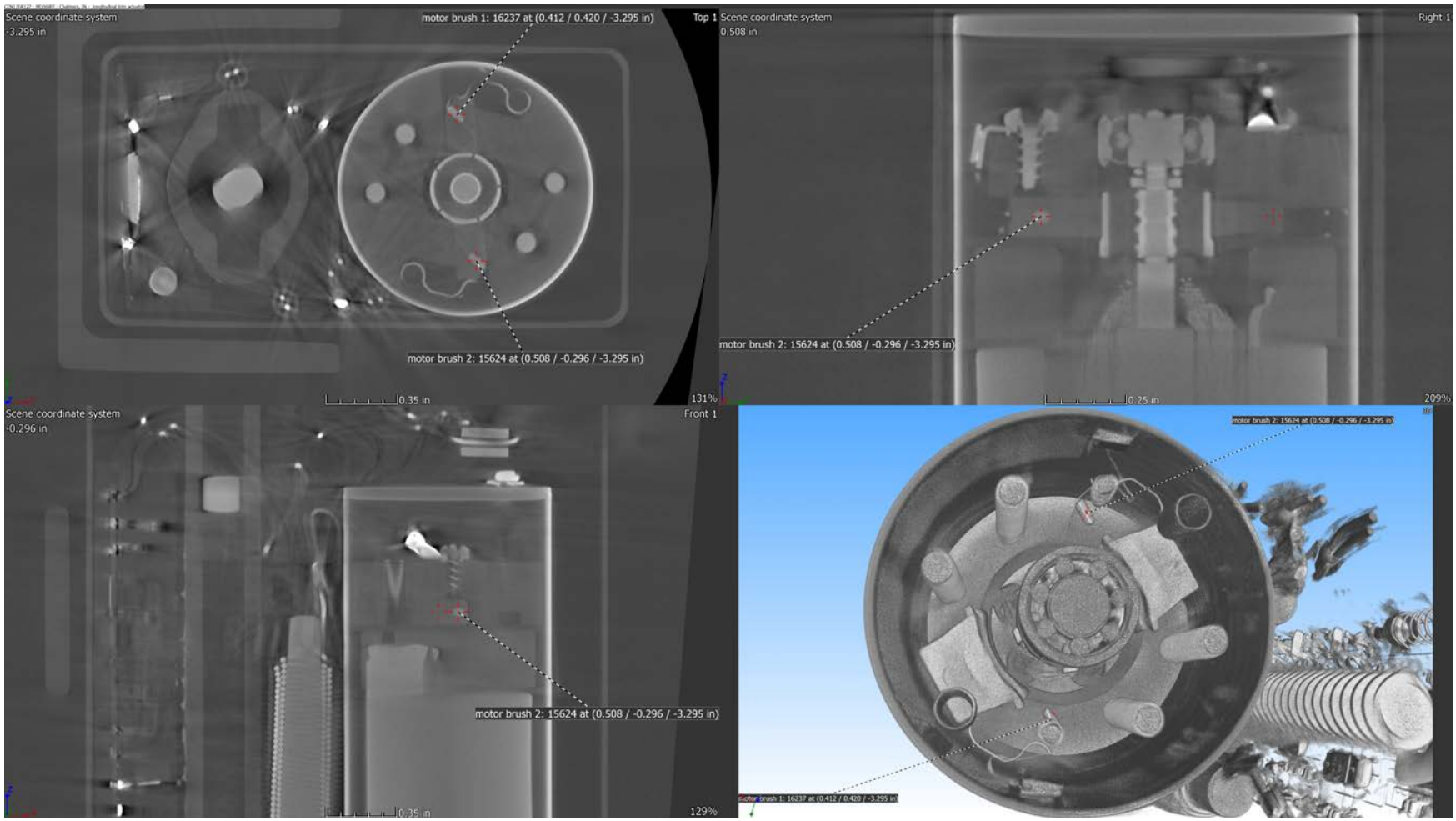

Figure 26
Longitudinal trim actuator – motor brush 2

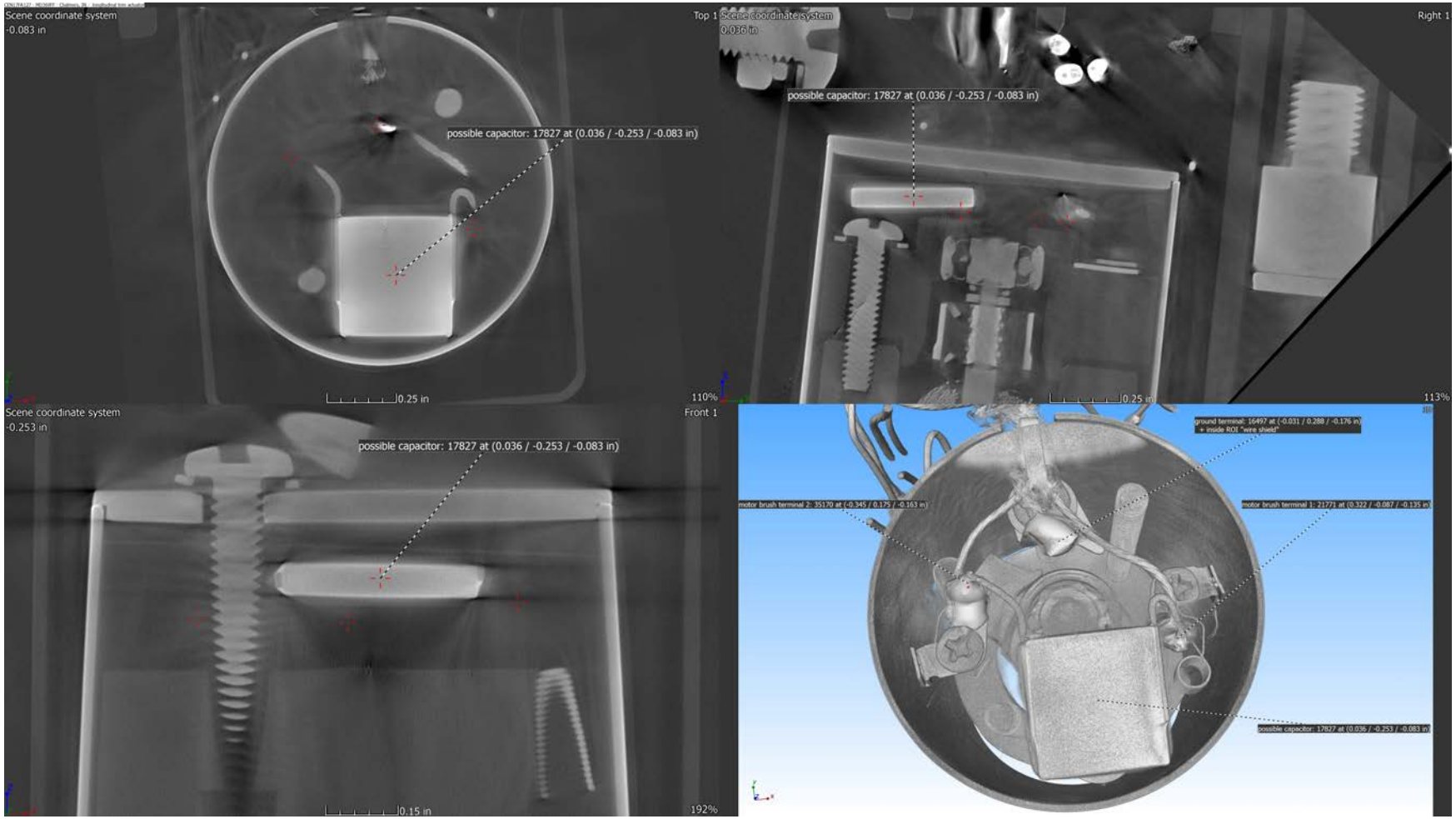

Figure 27
Longitudinal trim actuator – possible capacitor

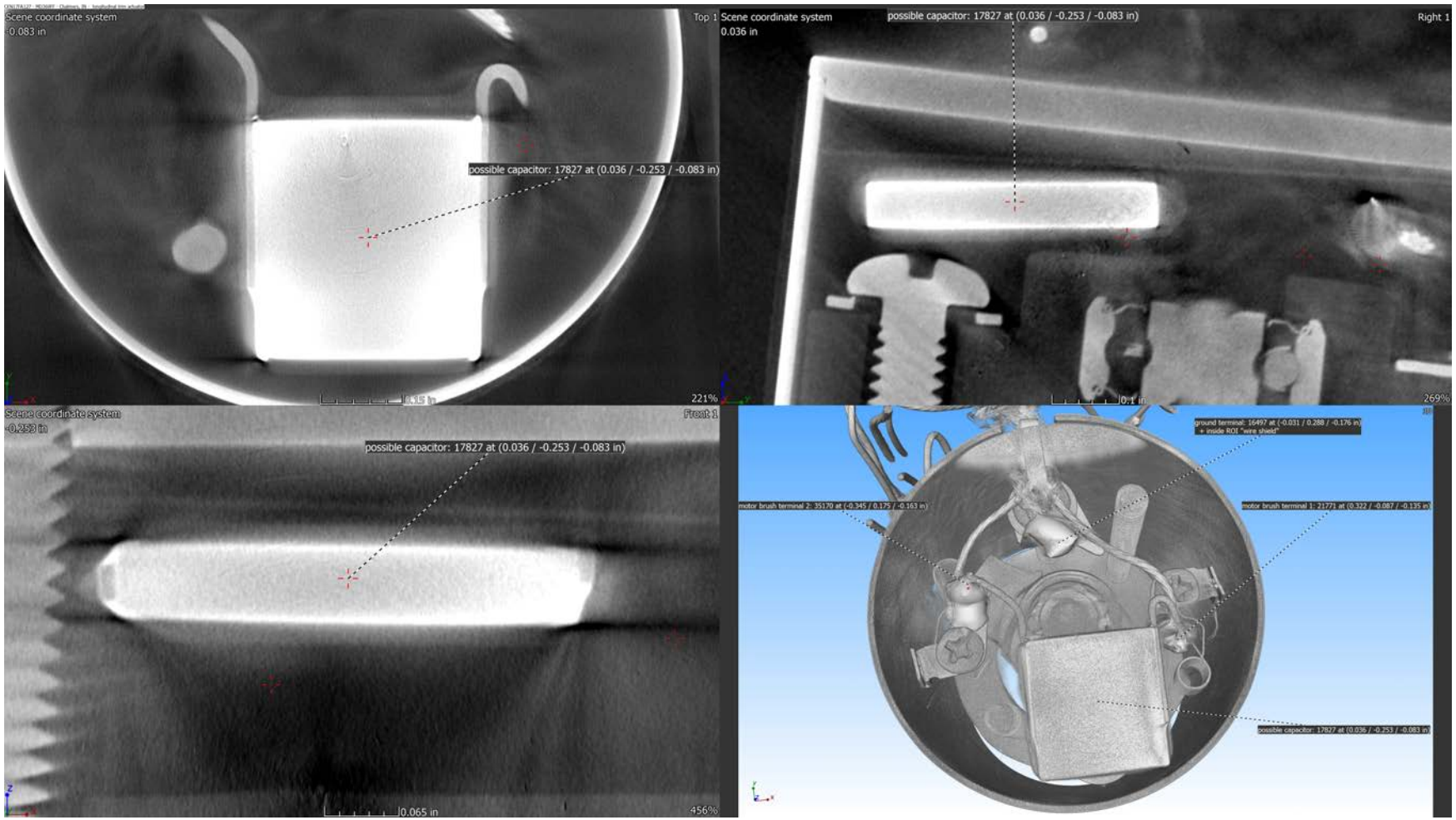

Figure 28
Longitudinal trim actuator – possible capacitor showing insulation

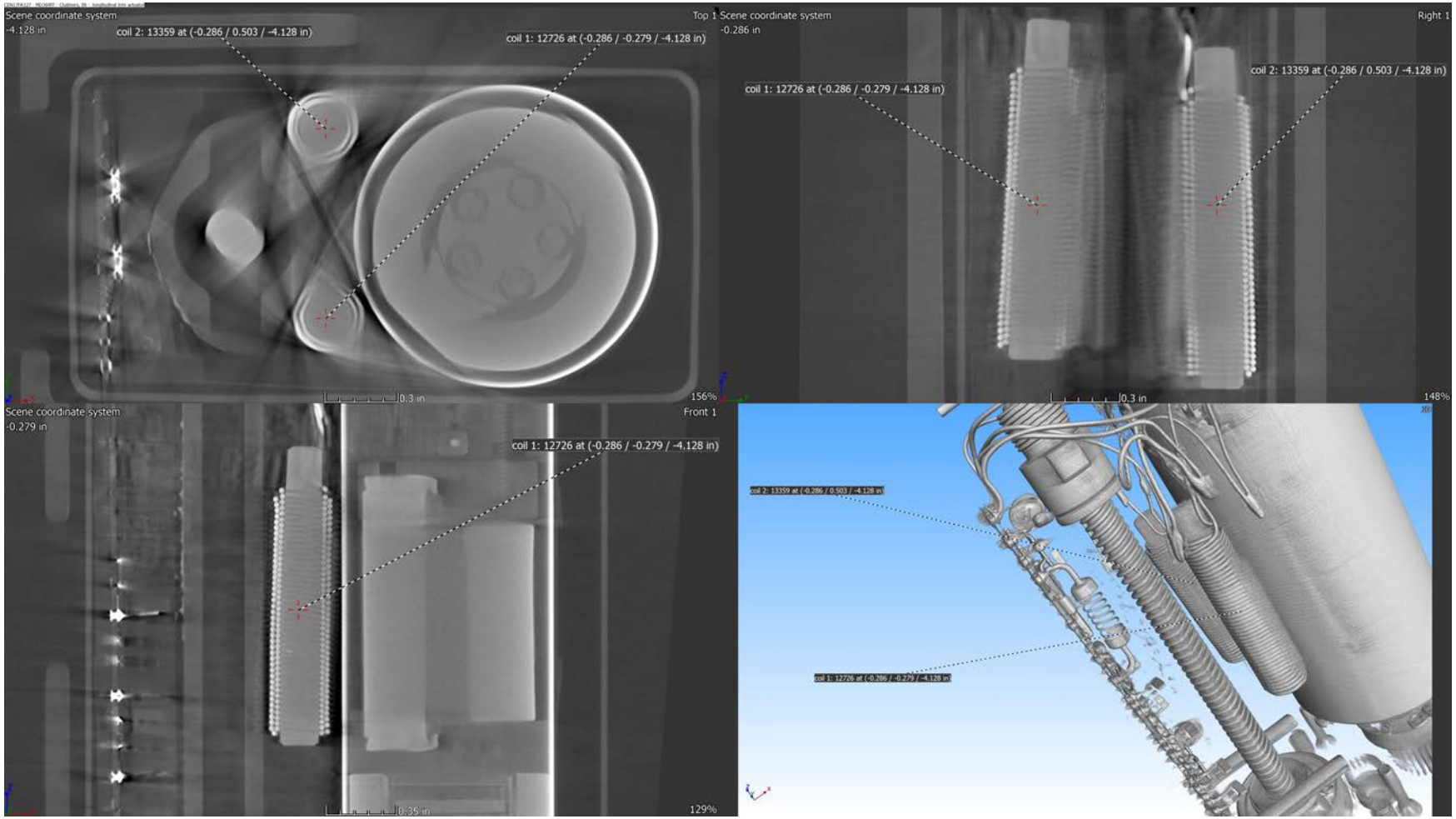

Figure 29
Longitudinal trim actuator – coil 1

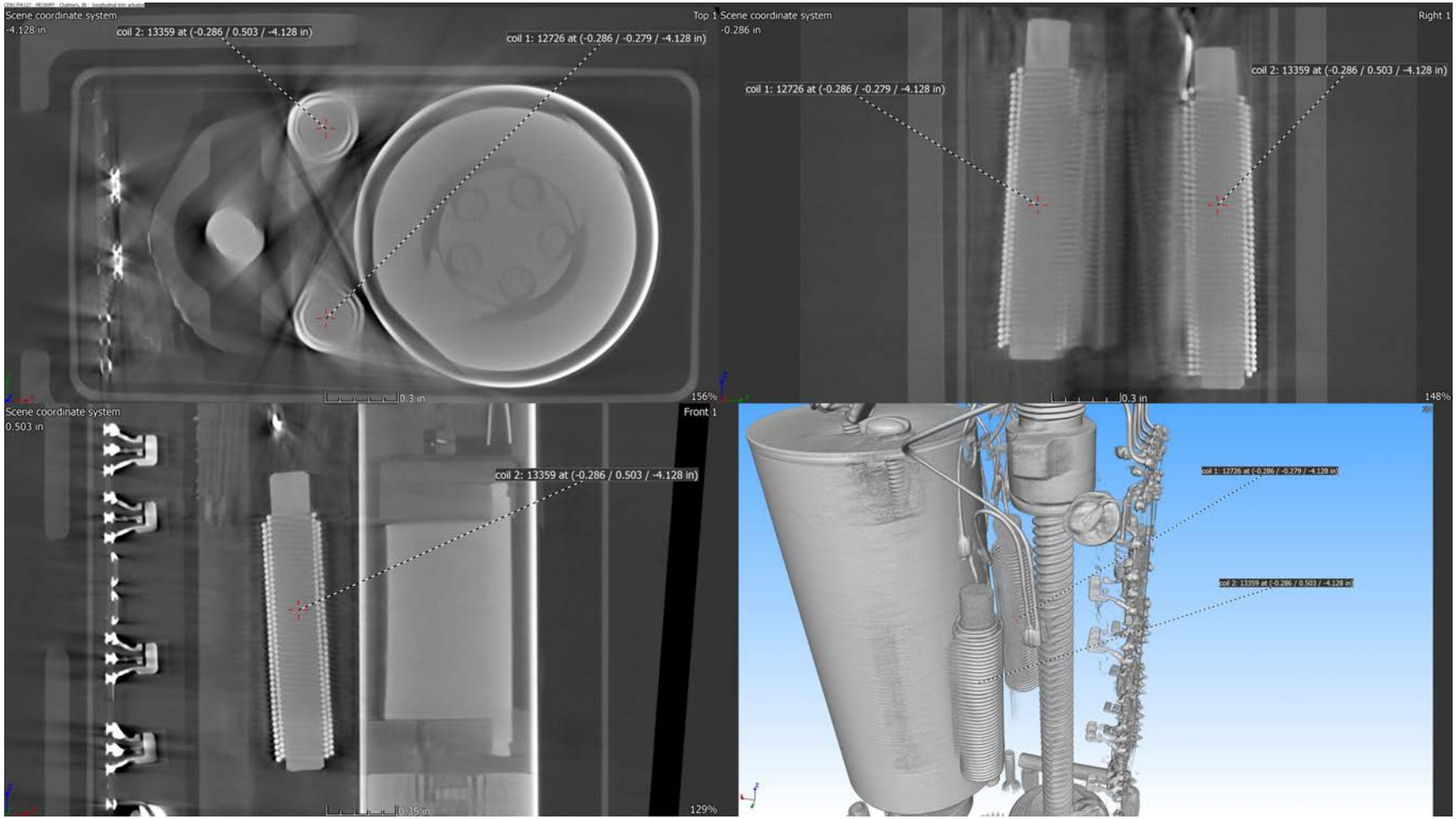

Figure 30
Longitudinal trim actuator – coil 2

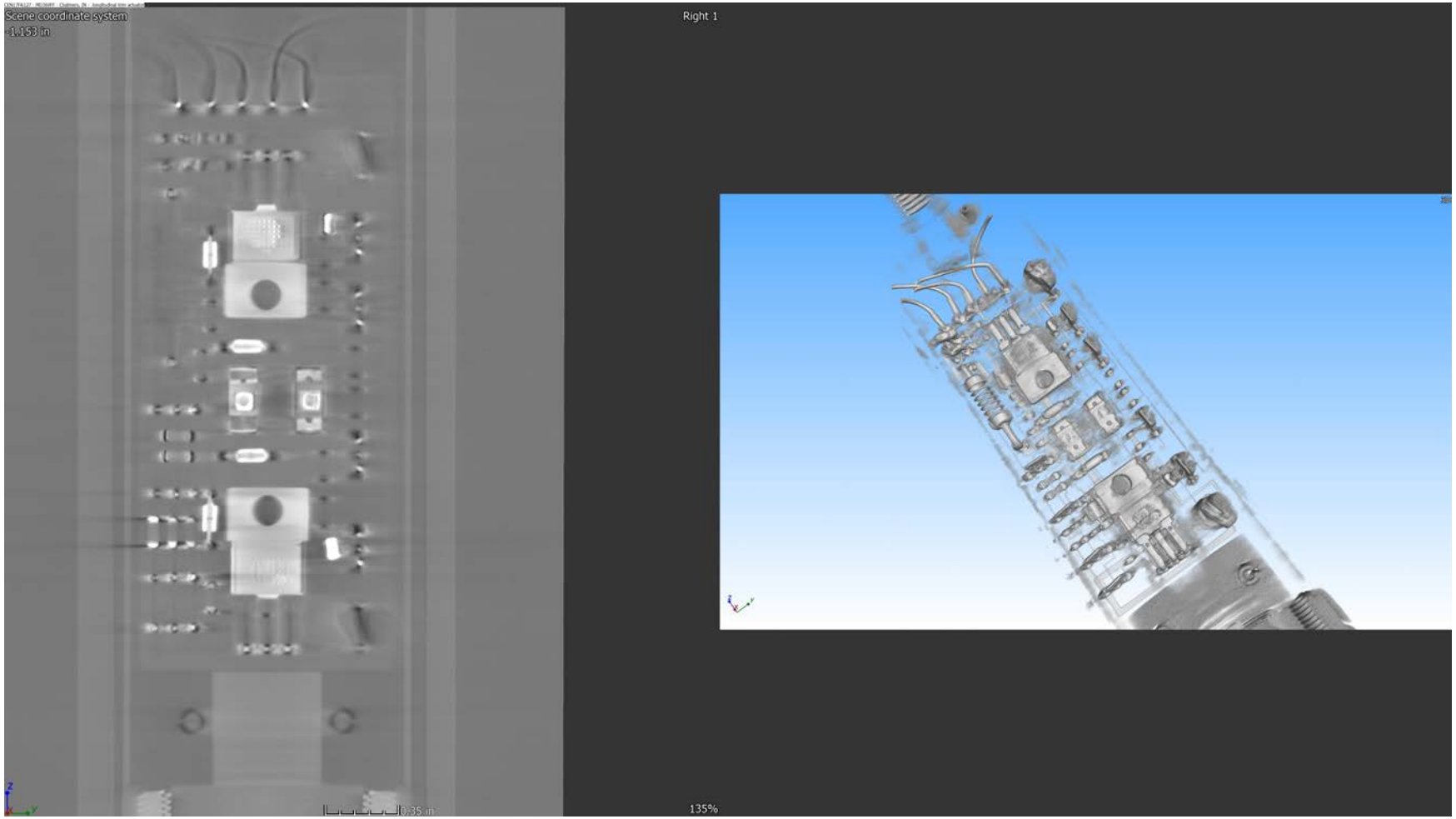

Figure 31
Longitudinal trim actuator – circuit board

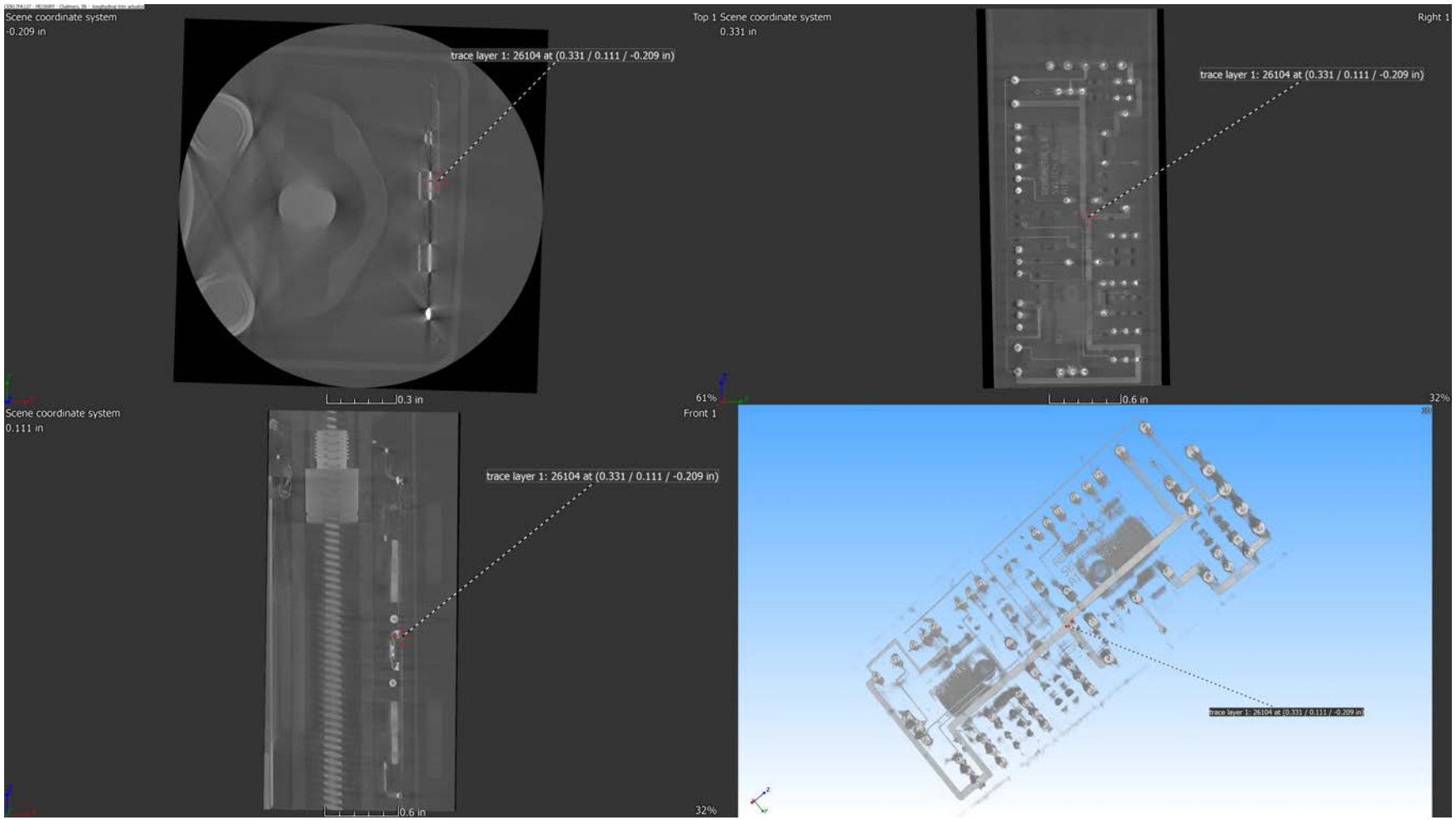

Figure 32
Longitudinal trim actuator – circuit board trace layer 1

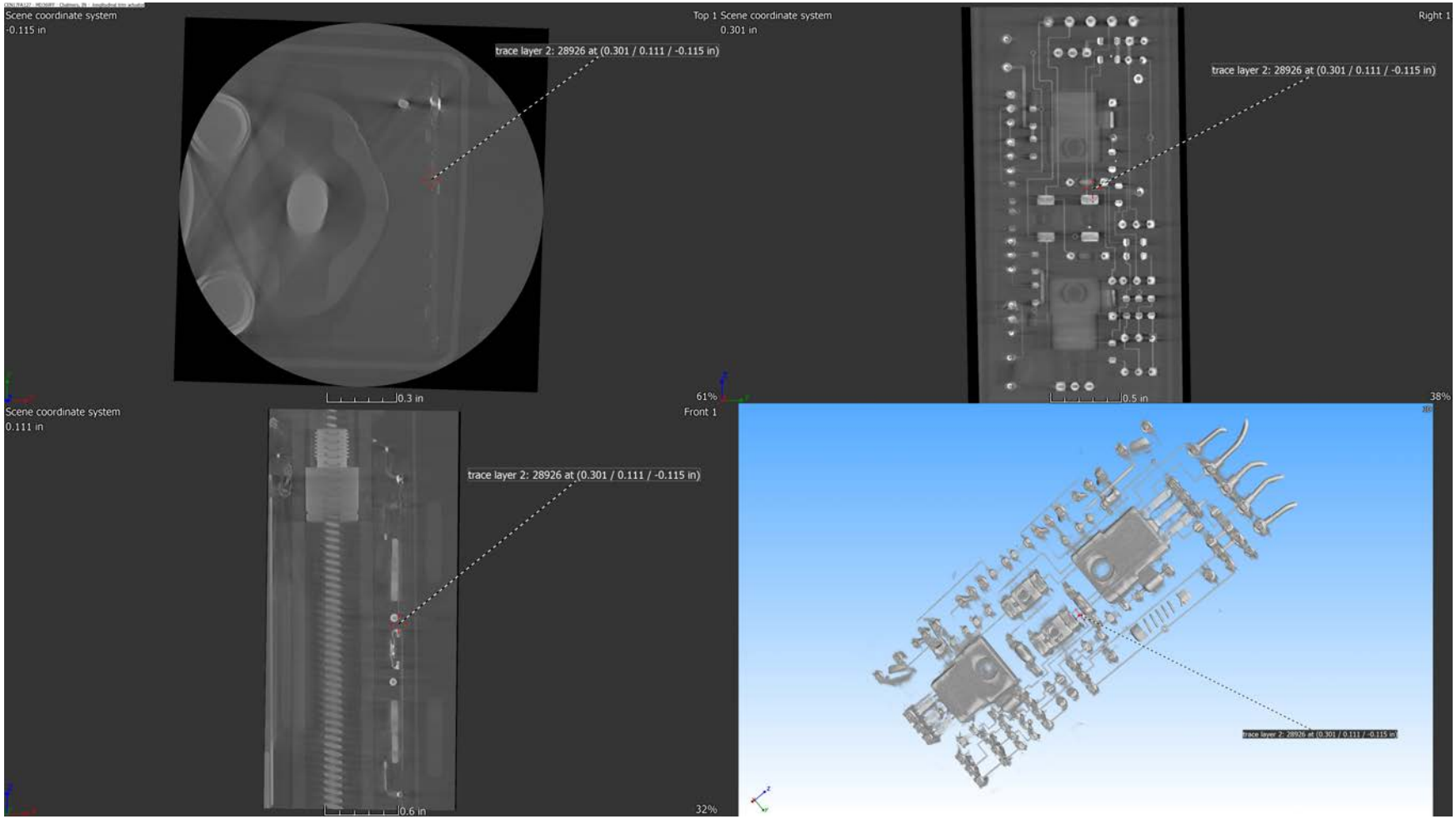

Figure 33
Longitudinal trim actuator – circuit board trace layer 2

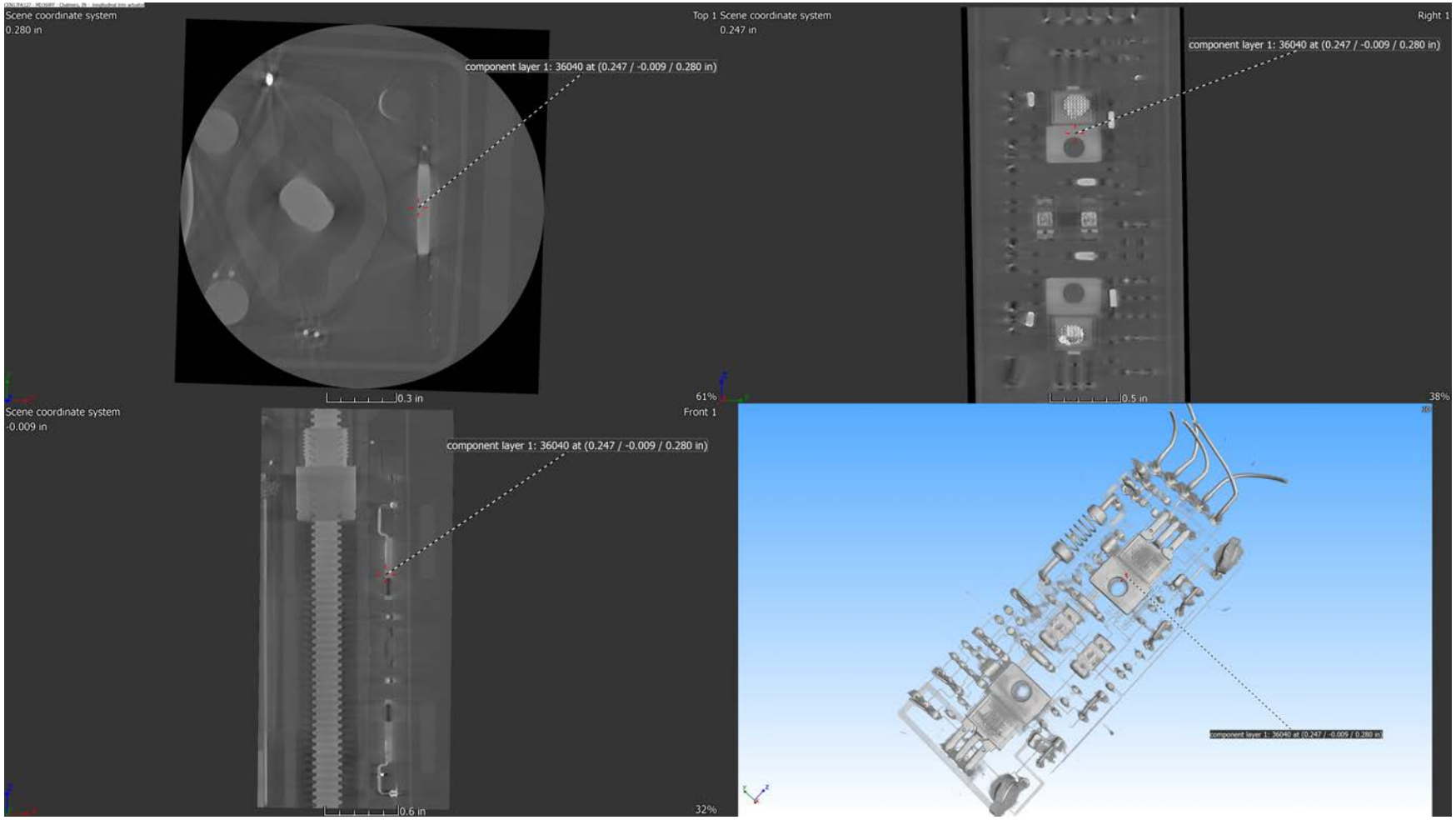

Figure 34
Longitudinal trim actuator – circuit board component layer 1

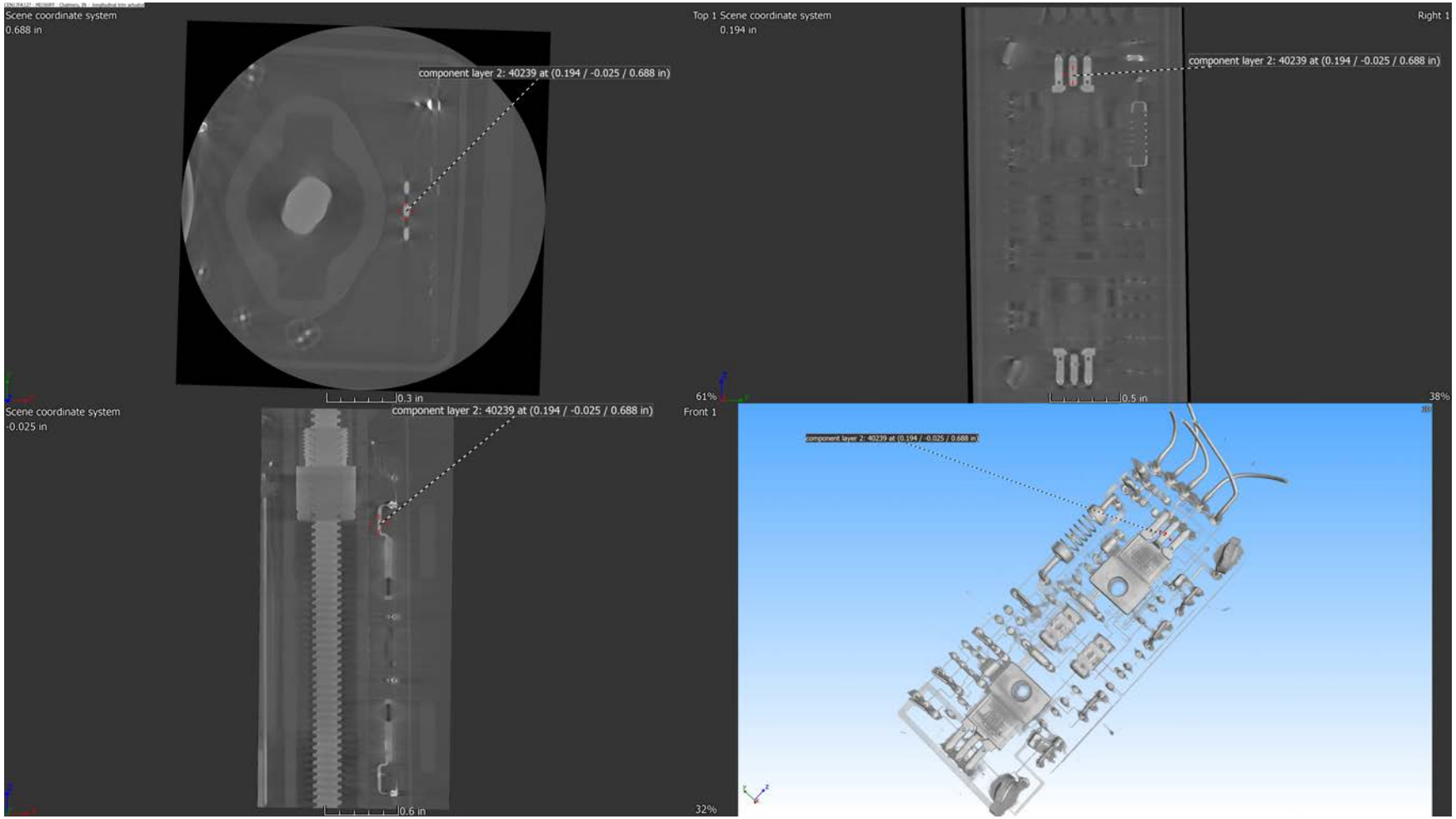

Figure 35
Longitudinal trim actuator – circuit board component layer 2

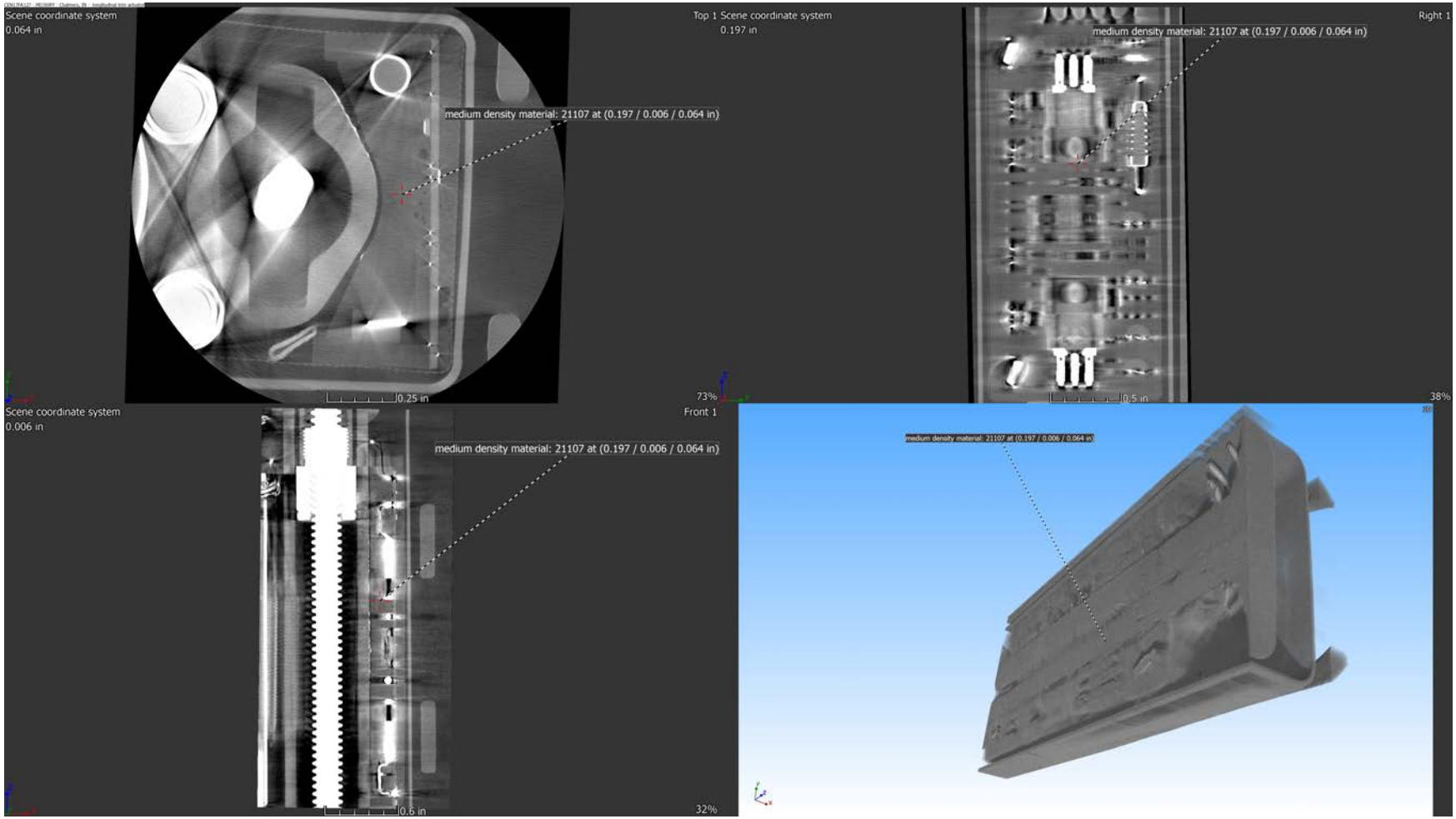

Figure 36
Longitudinal trim actuator – circuit board medium density material

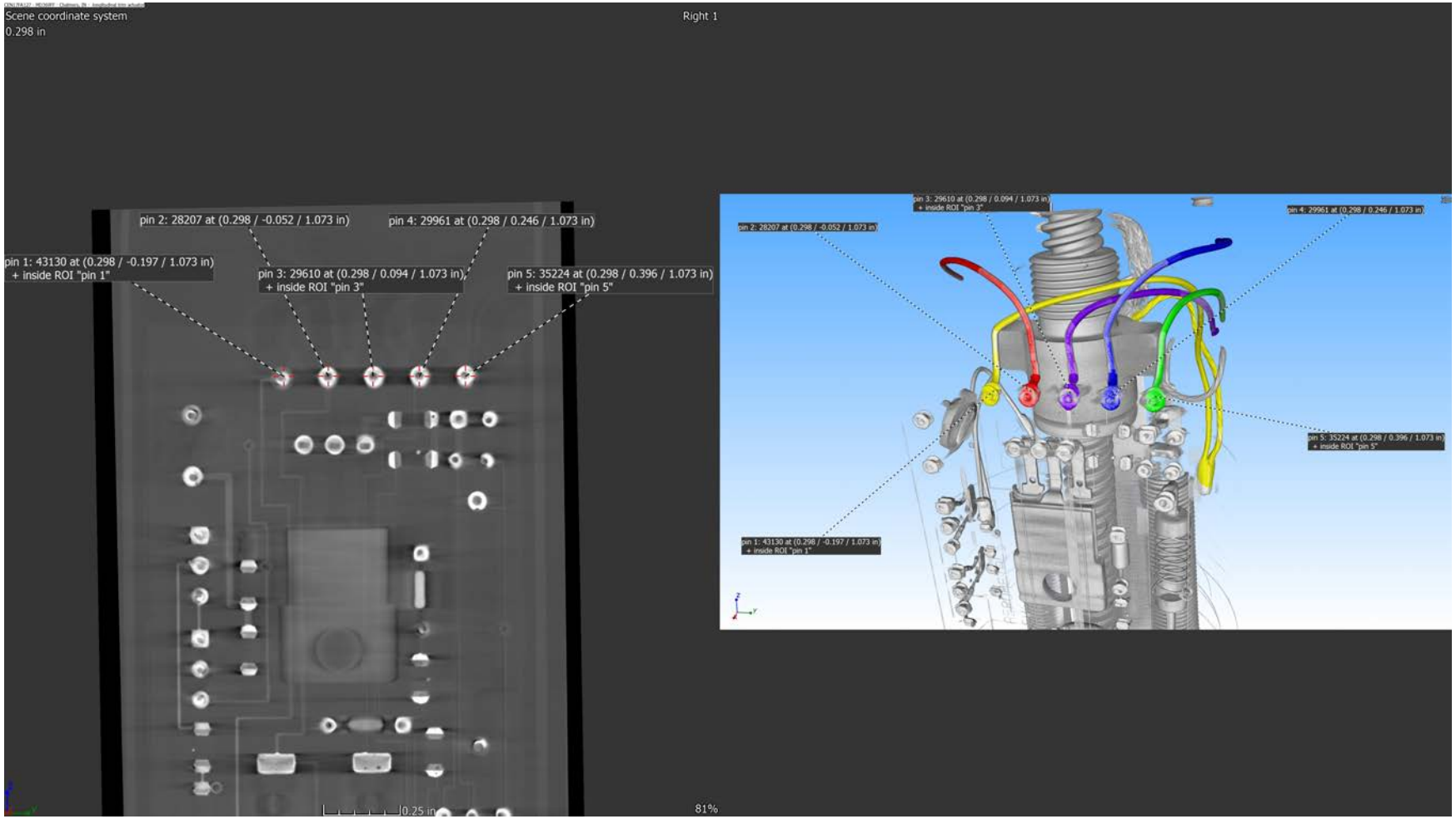

Figure 37
Longitudinal trim actuator – circuit board wires side 1

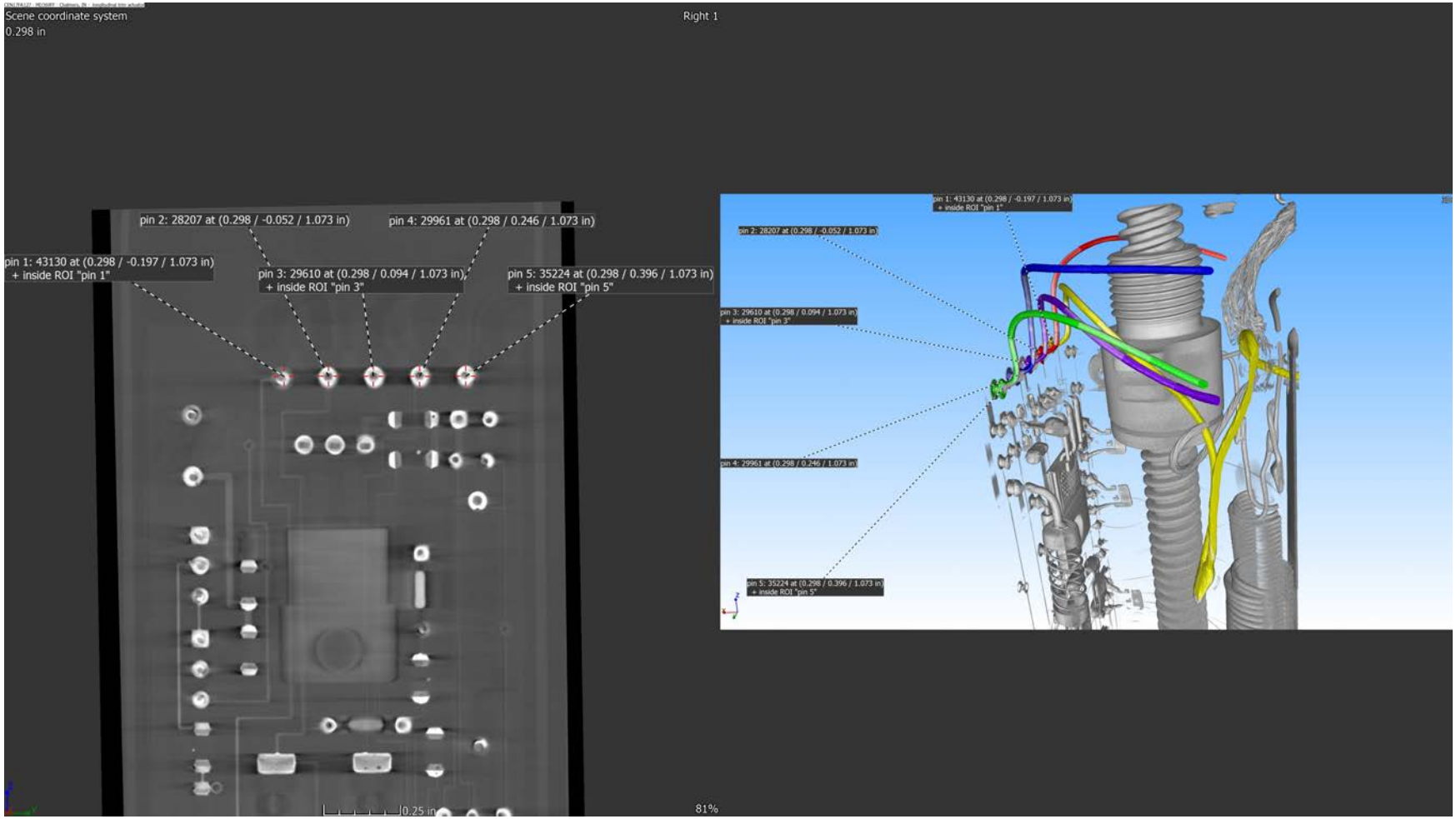

Figure 38
Longitudinal trim actuator – circuit board wires side 2

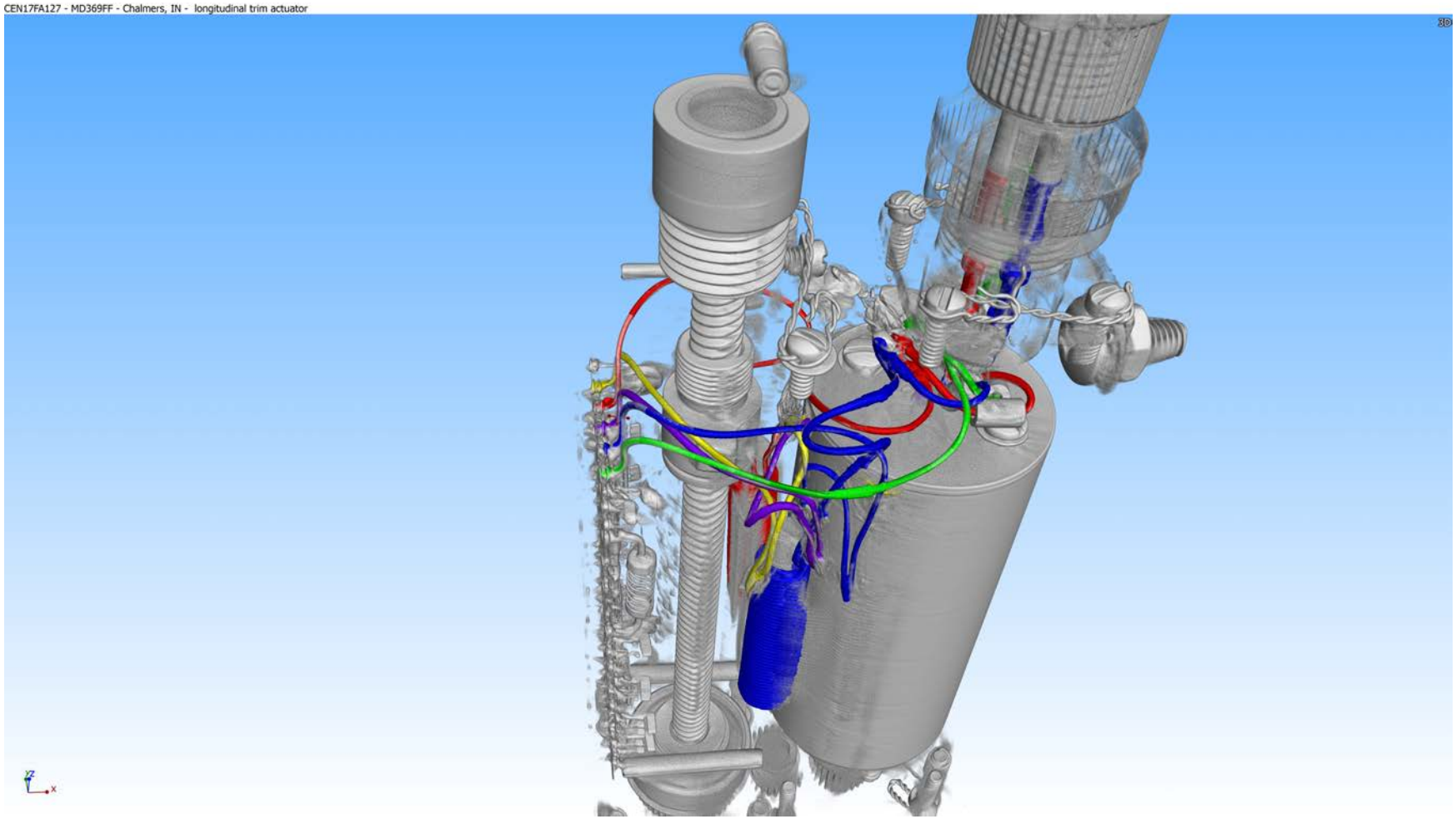

Figure 39
Longitudinal trim actuator – circuit board wires view 1

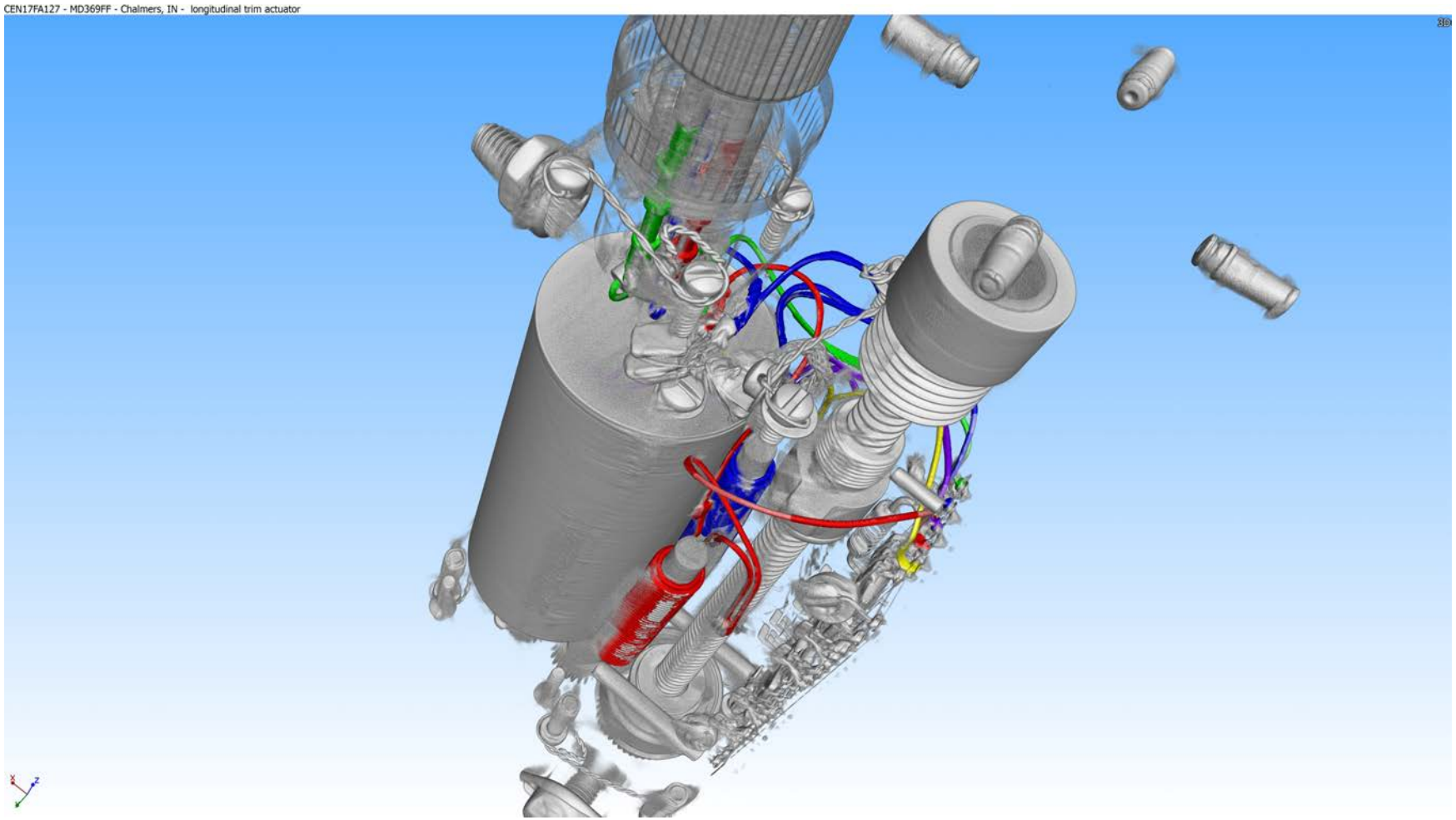

Figure 40
Longitudinal trim actuator – circuit board wires view 2

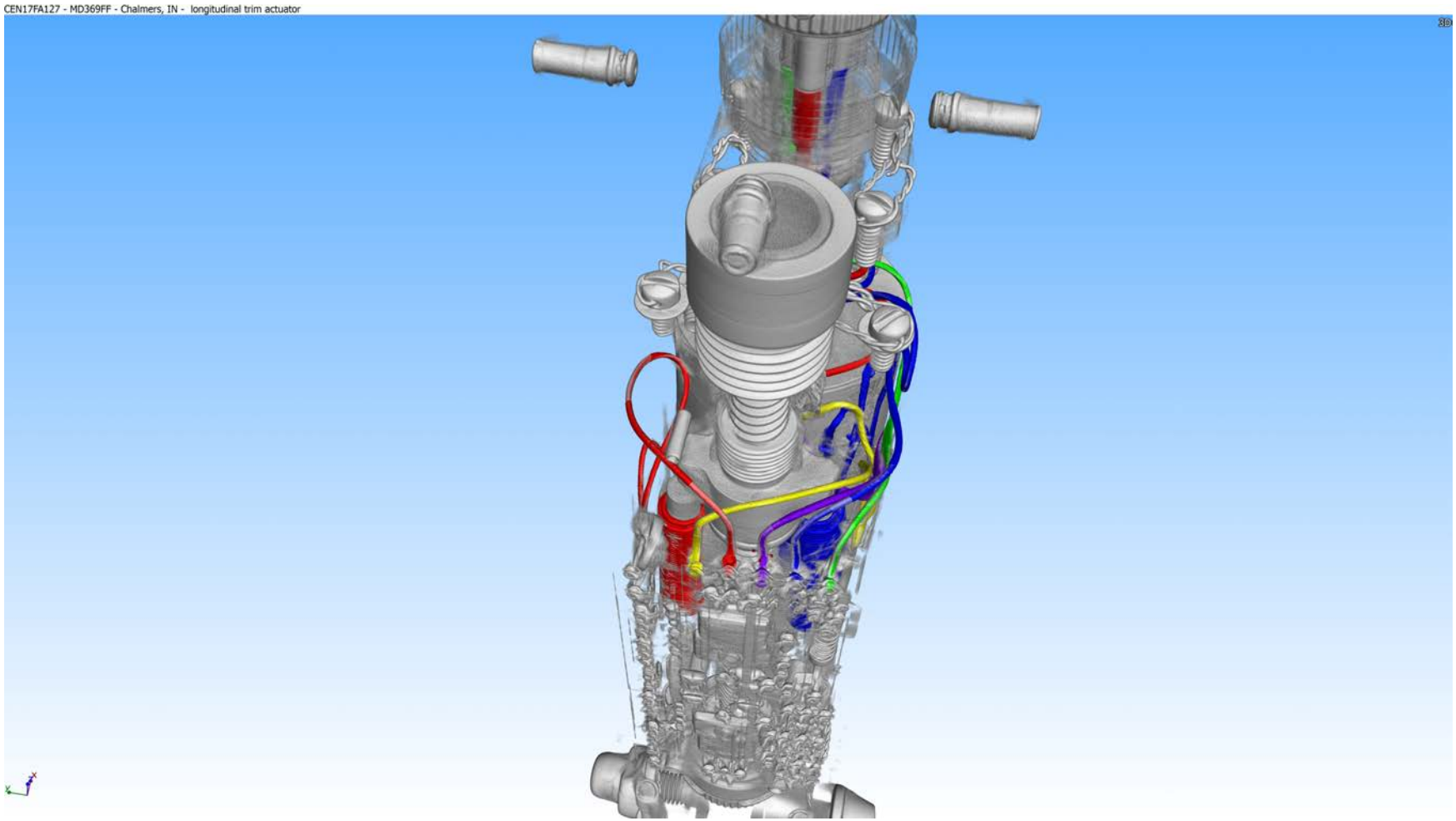

Figure 41
Longitudinal trim actuator – circuit board wires view 3

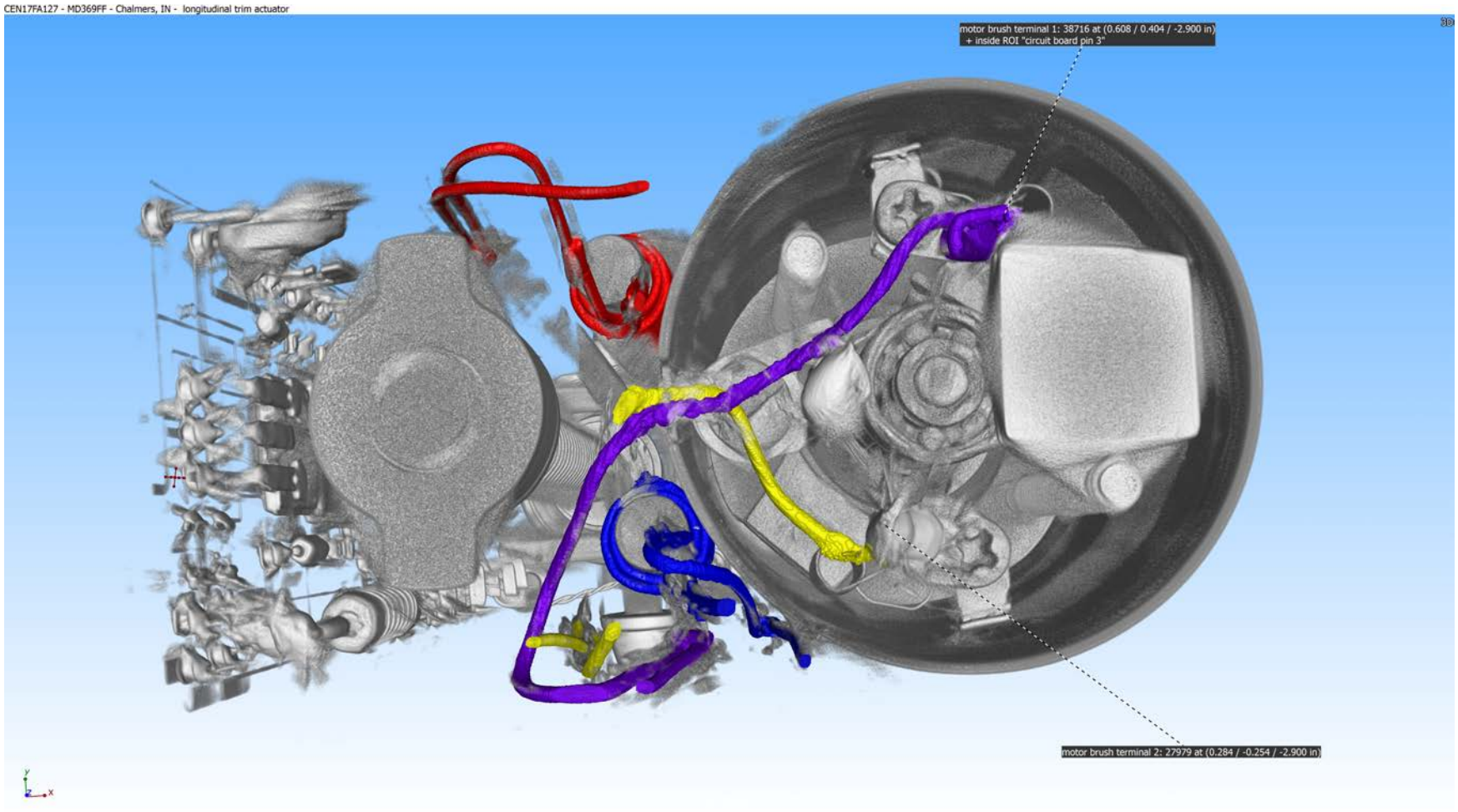

Figure 42
Longitudinal trim actuator – circuit board wires view 4

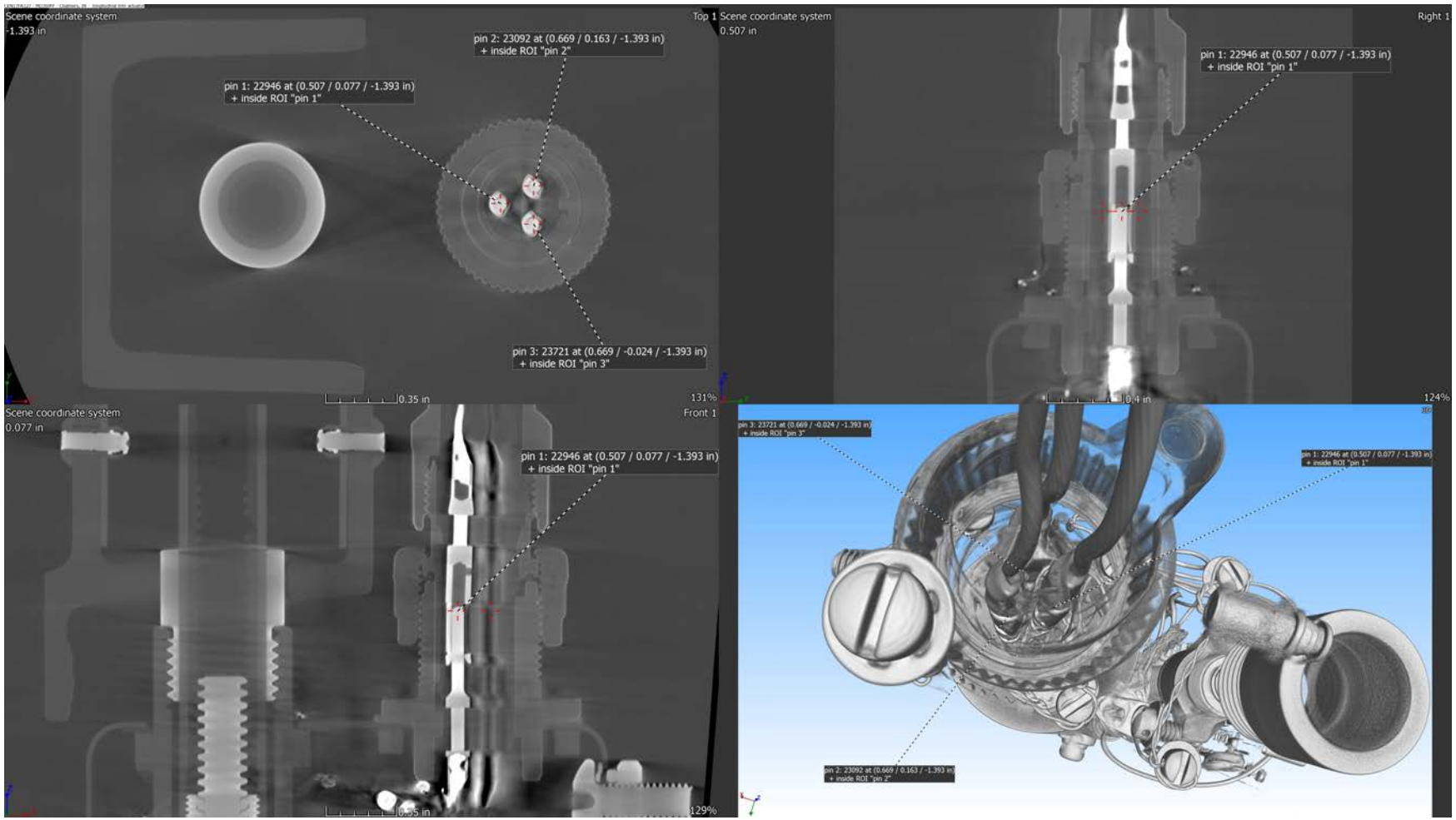

Figure 43
Longitudinal trim actuator – connector pin 1

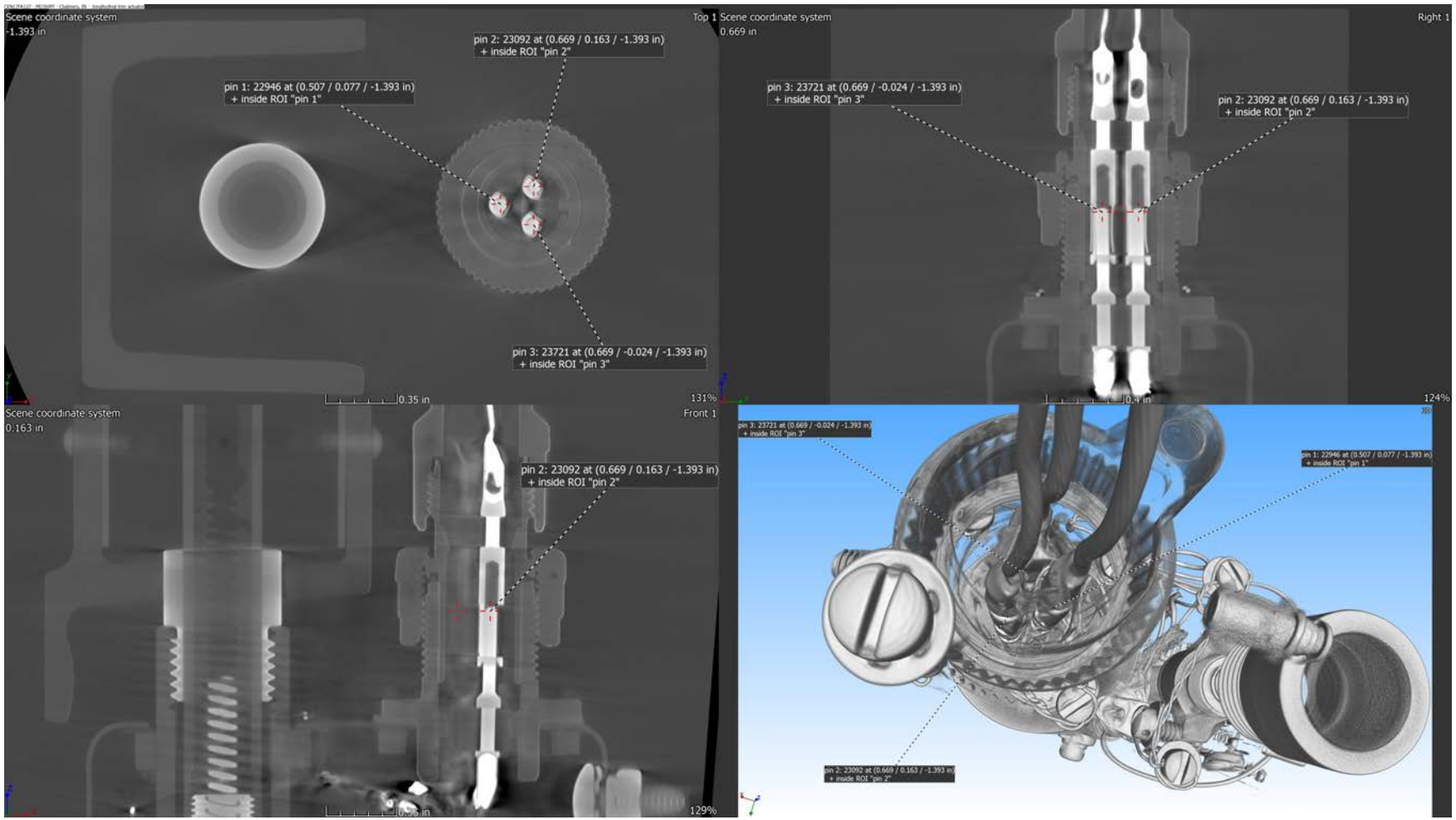

Figure 44
Longitudinal trim actuator – connector pins 2 and 3

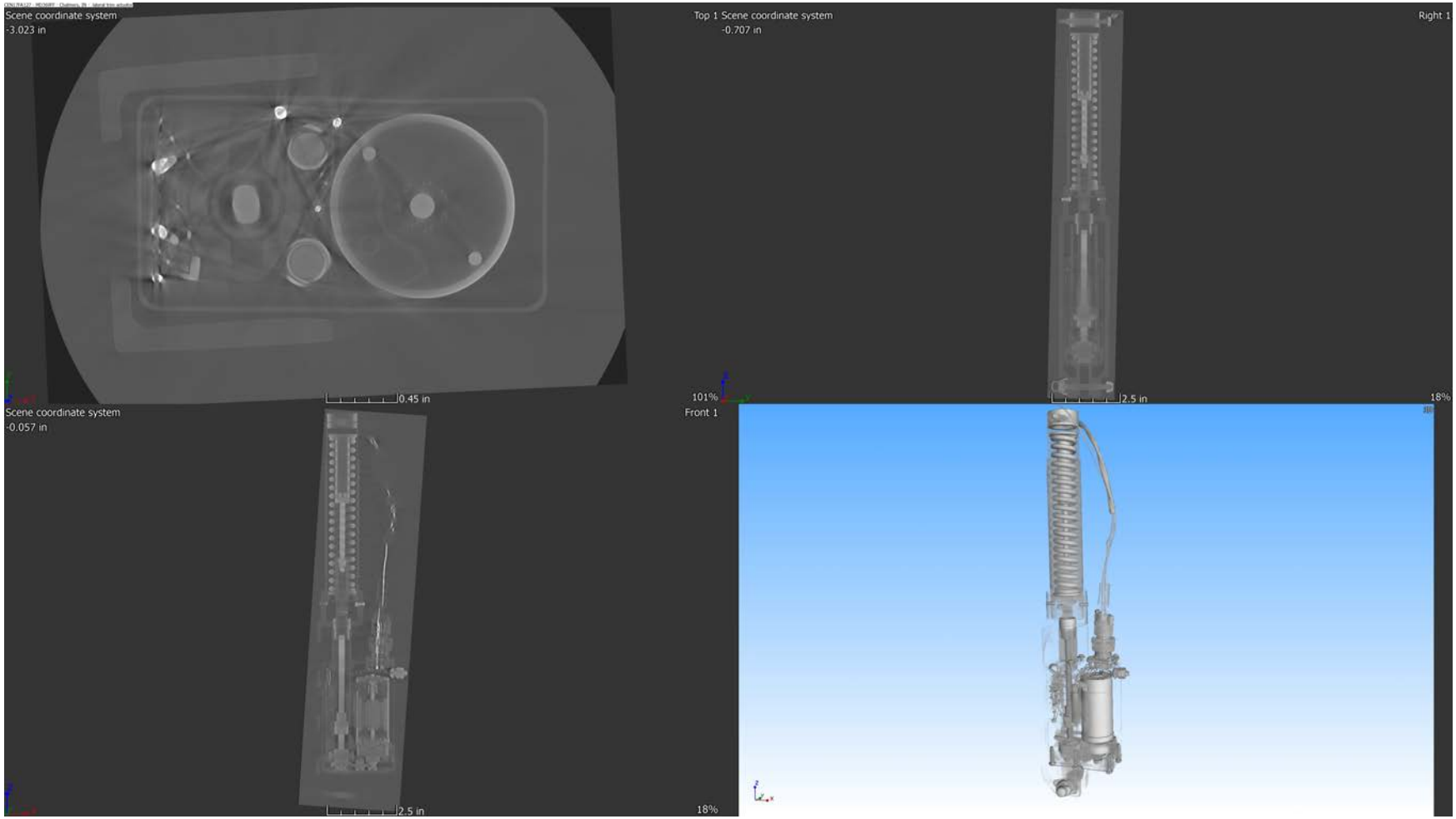

Figure 45
Lateral trim actuator – overview

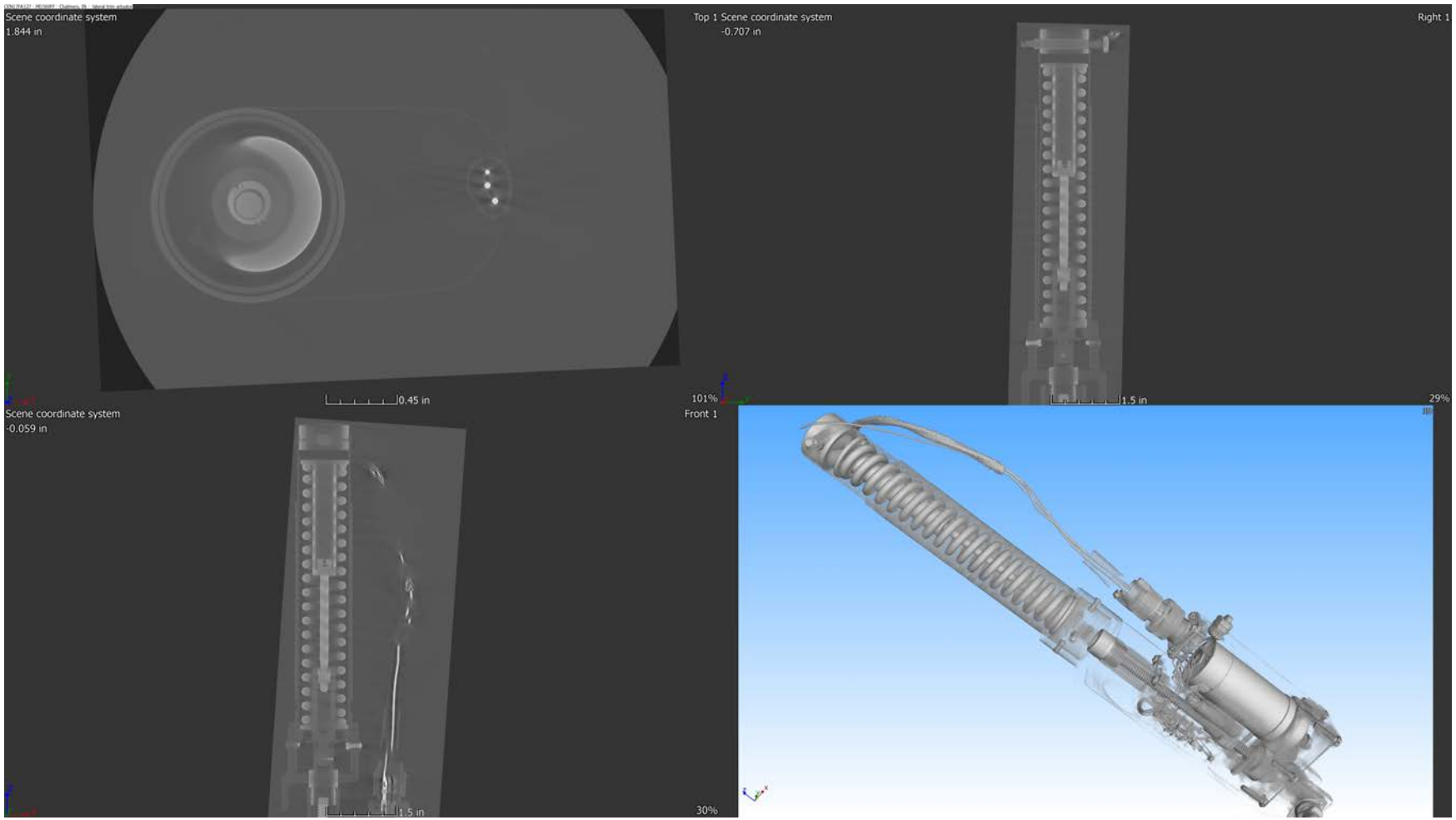

Figure 46
Lateral trim actuator – spring

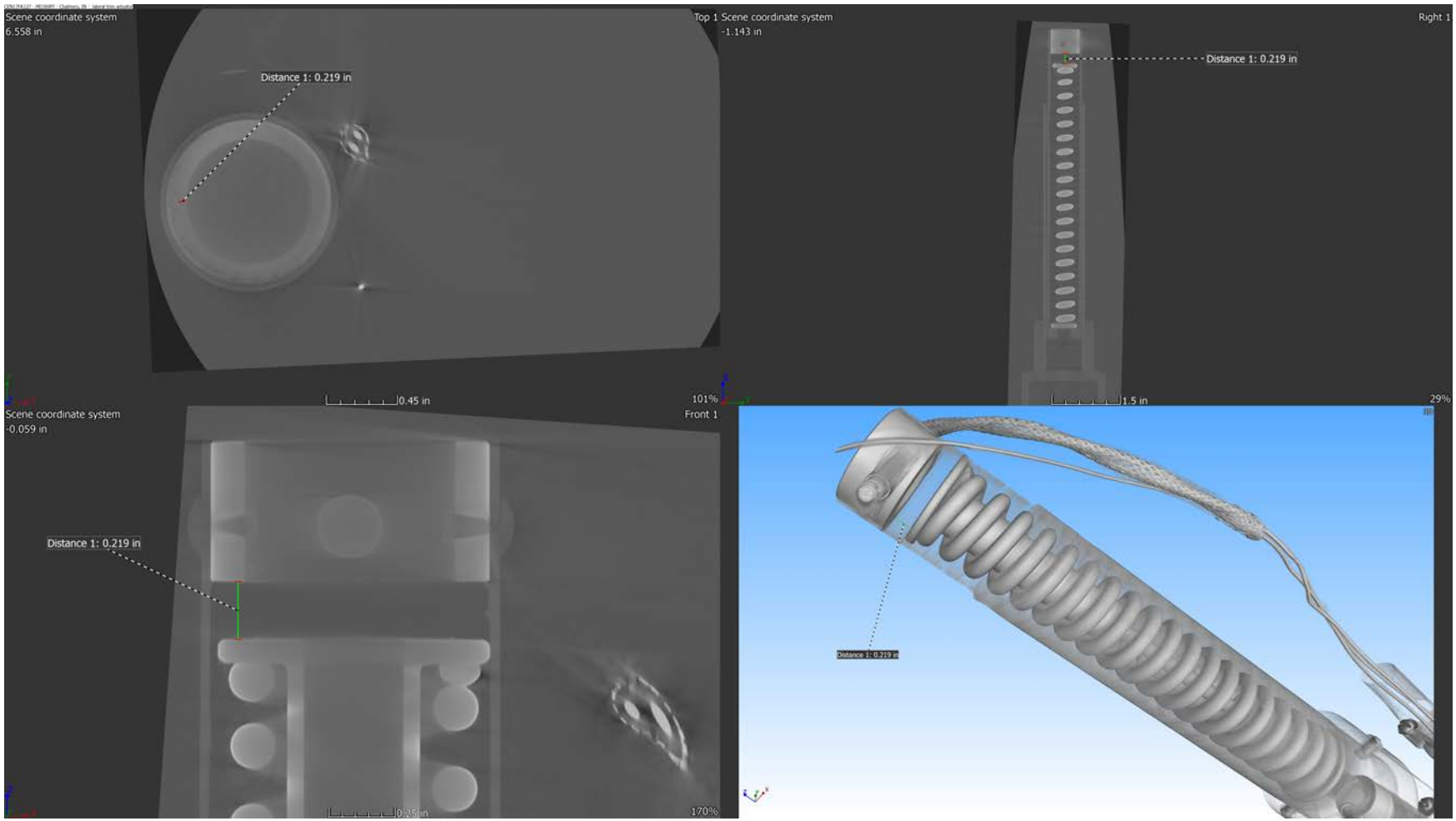

Figure 47
Lateral trim actuator – gap

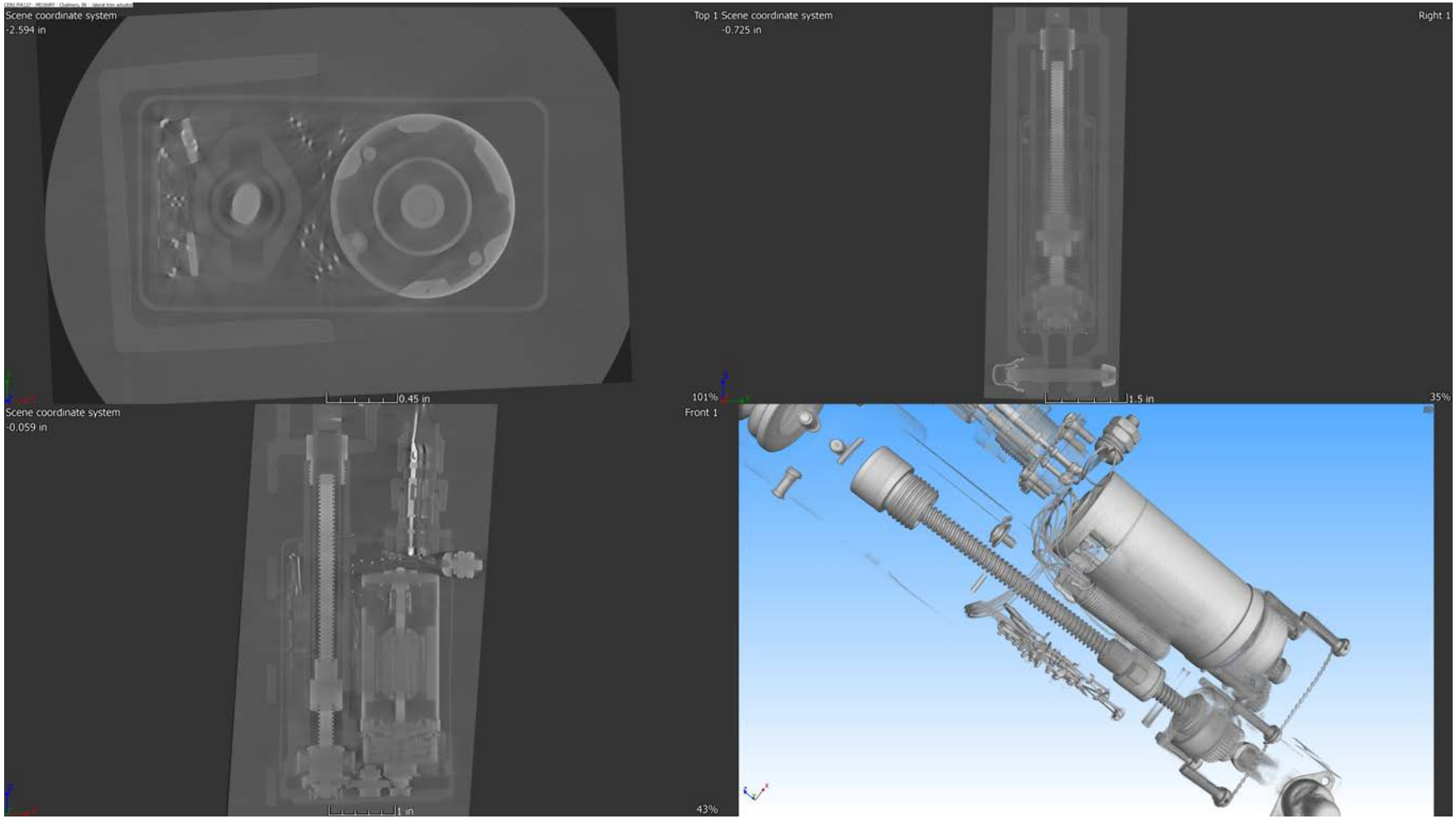

Figure 48
Lateral trim actuator – screw

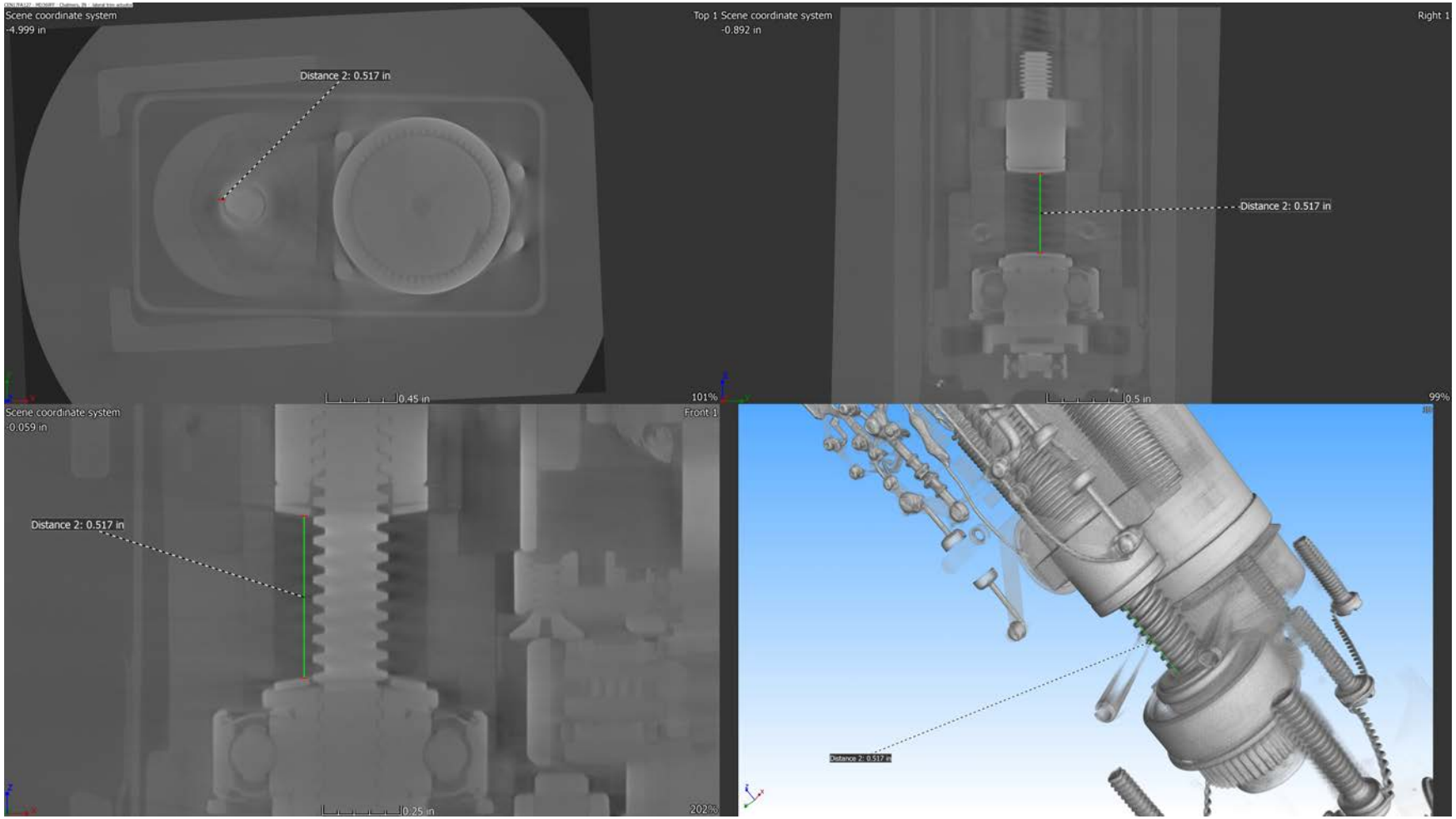

Figure 49
Lateral trim actuator – screw dimension

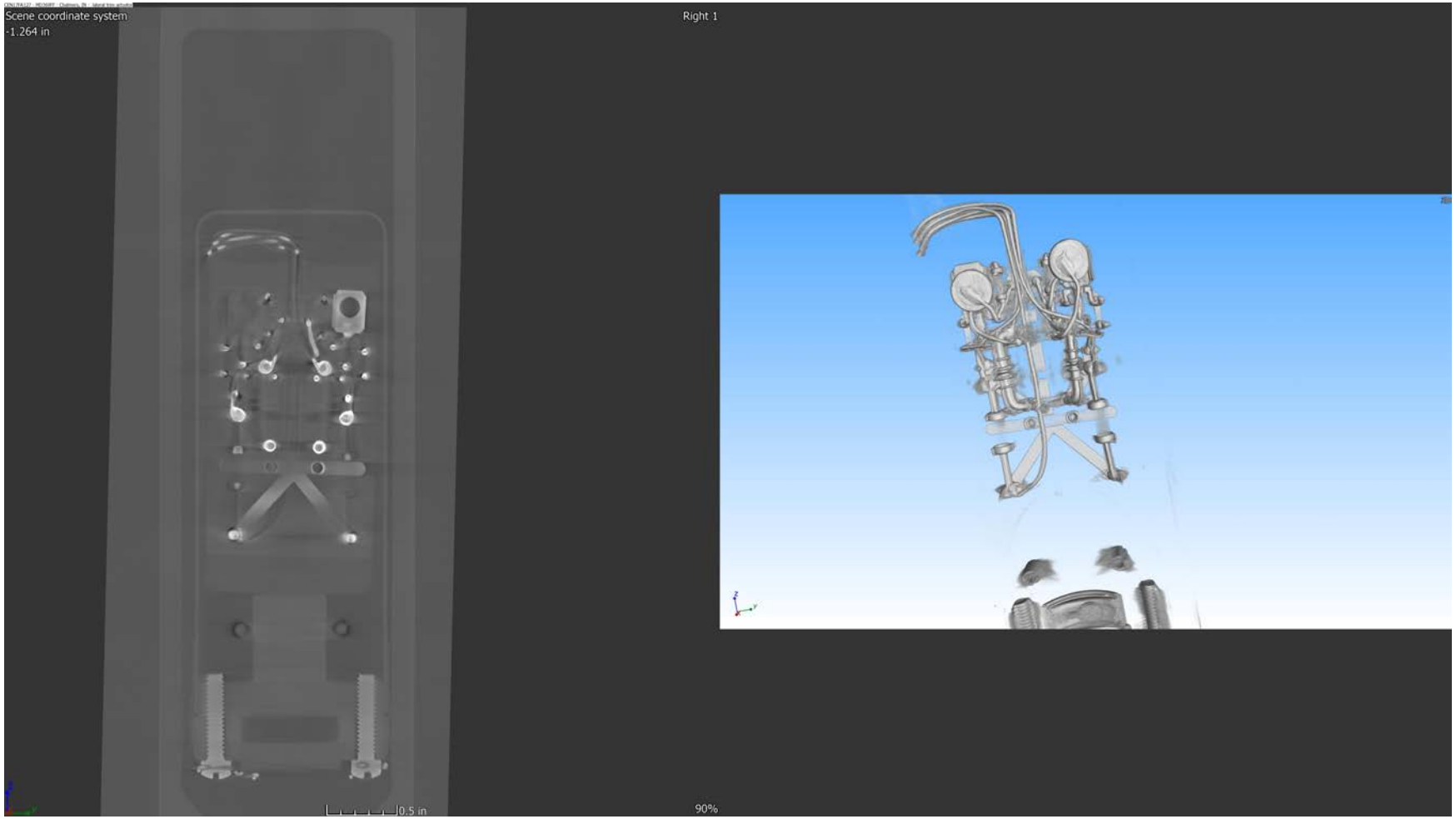

Figure 50
Lateral trim actuator – circuit board

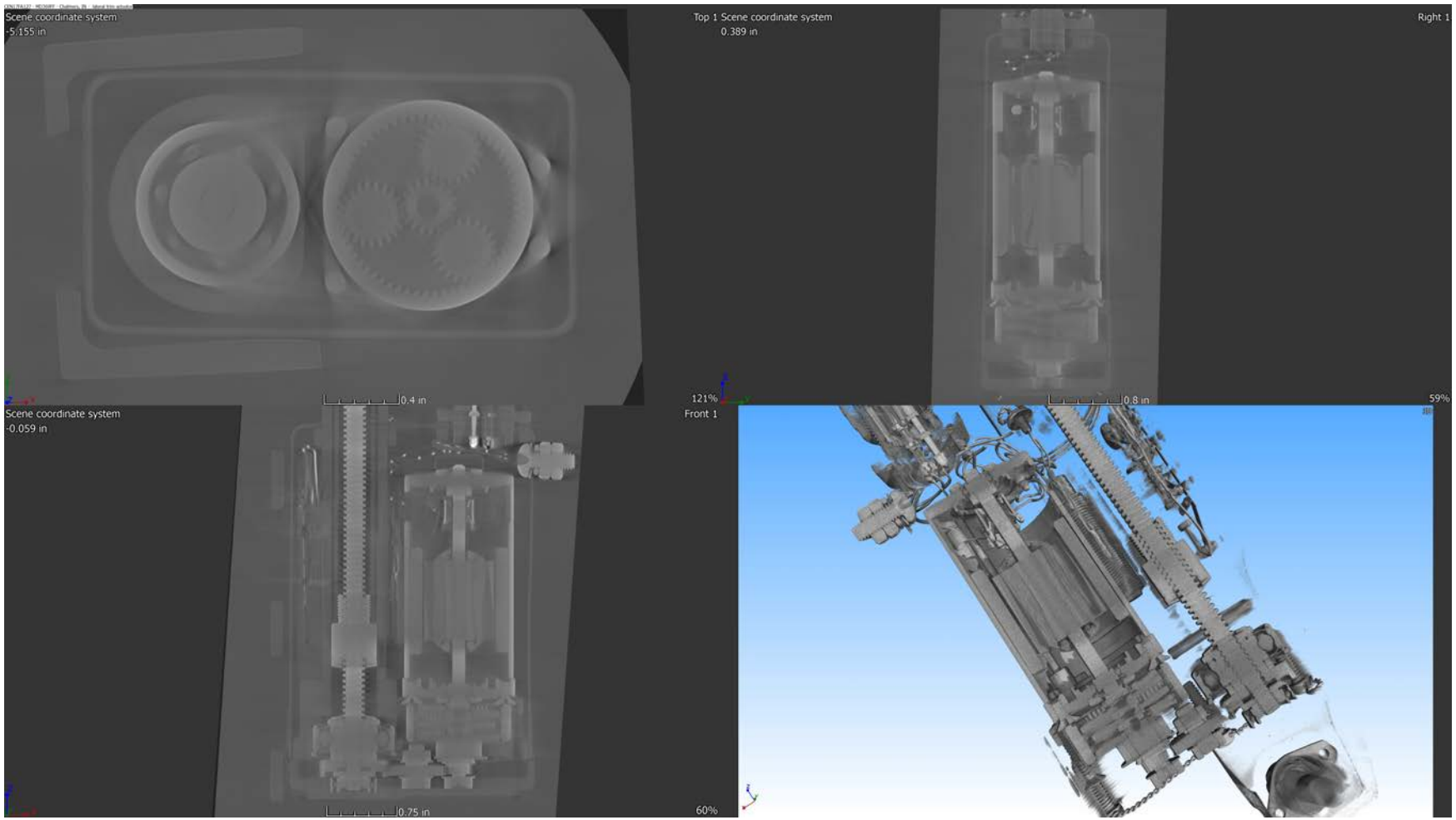

Figure 51
Lateral trim actuator – motor and gear train

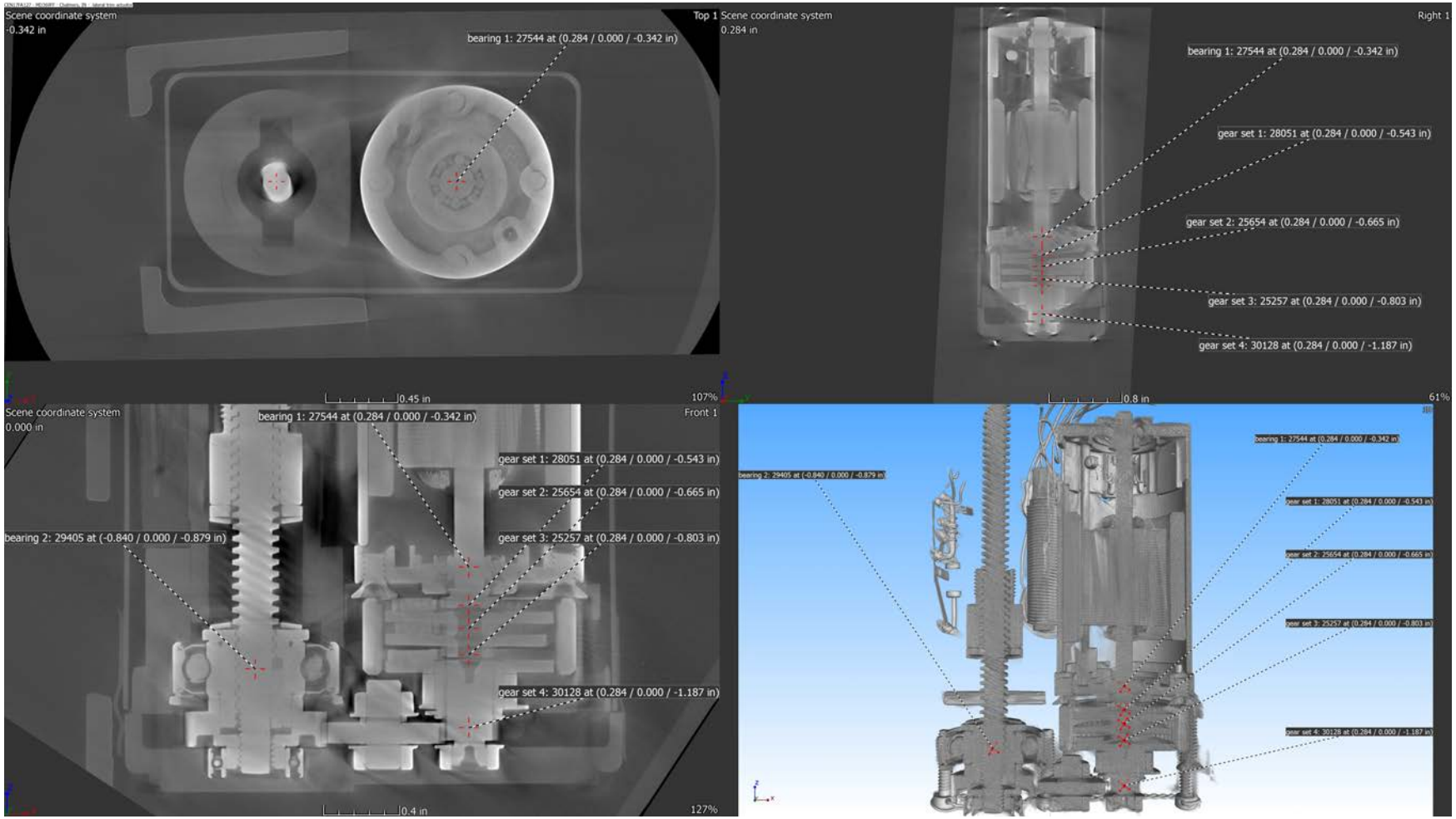

Figure 52
Lateral trim actuator – gear set and bearing overview

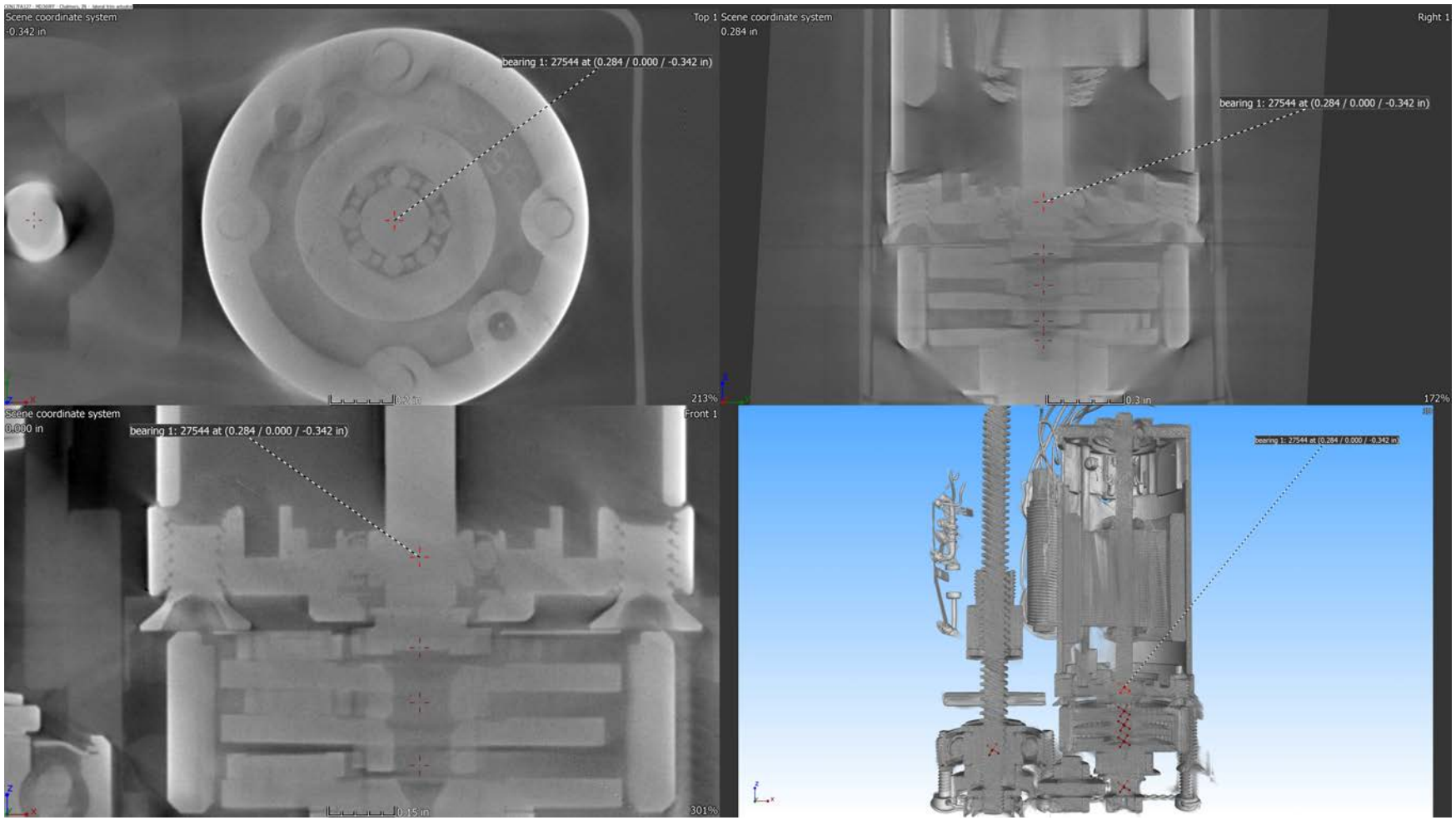

Figure 53
Lateral trim actuator – bearing 1

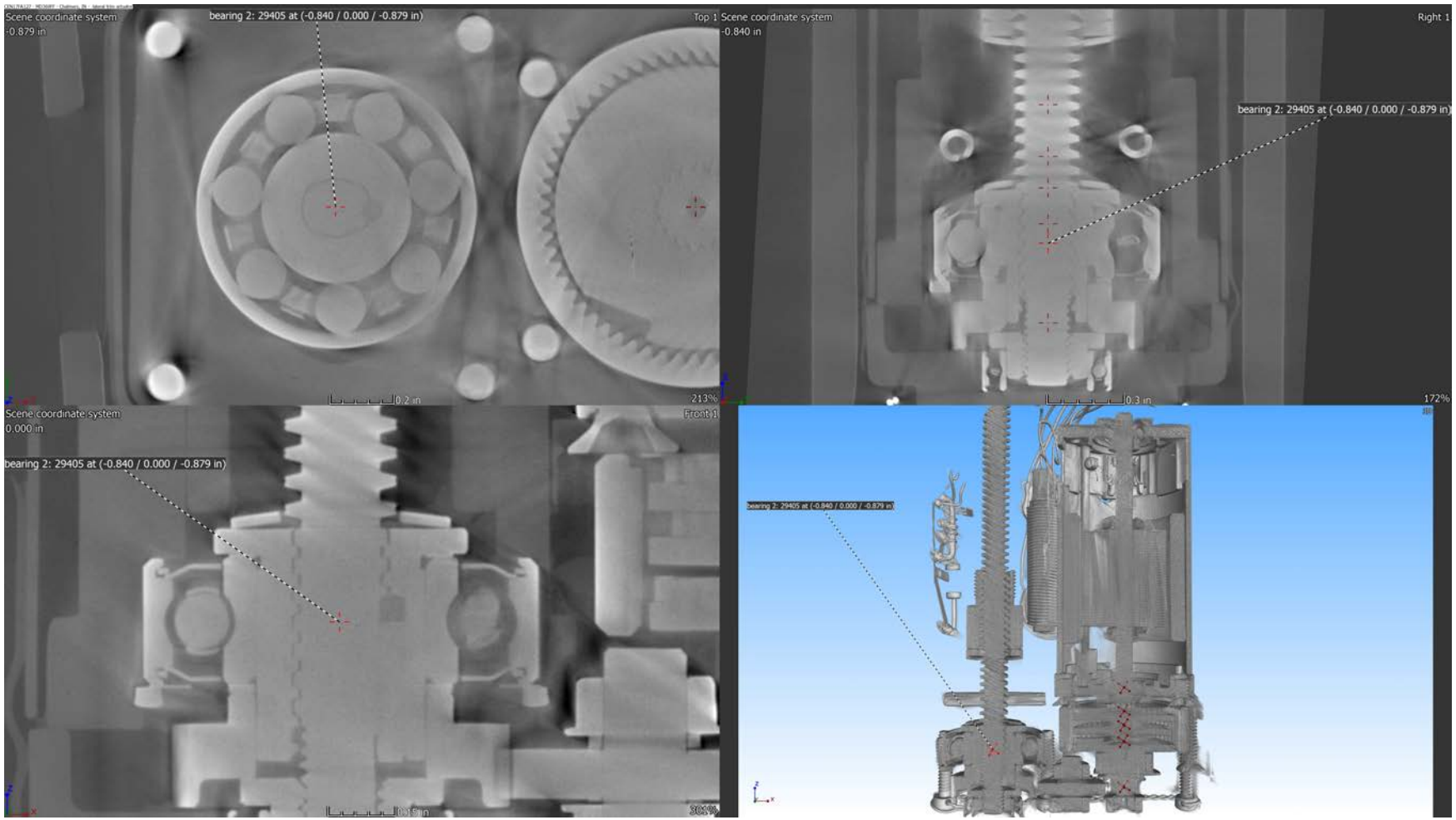

Figure 54
Lateral trim actuator – bearing 2

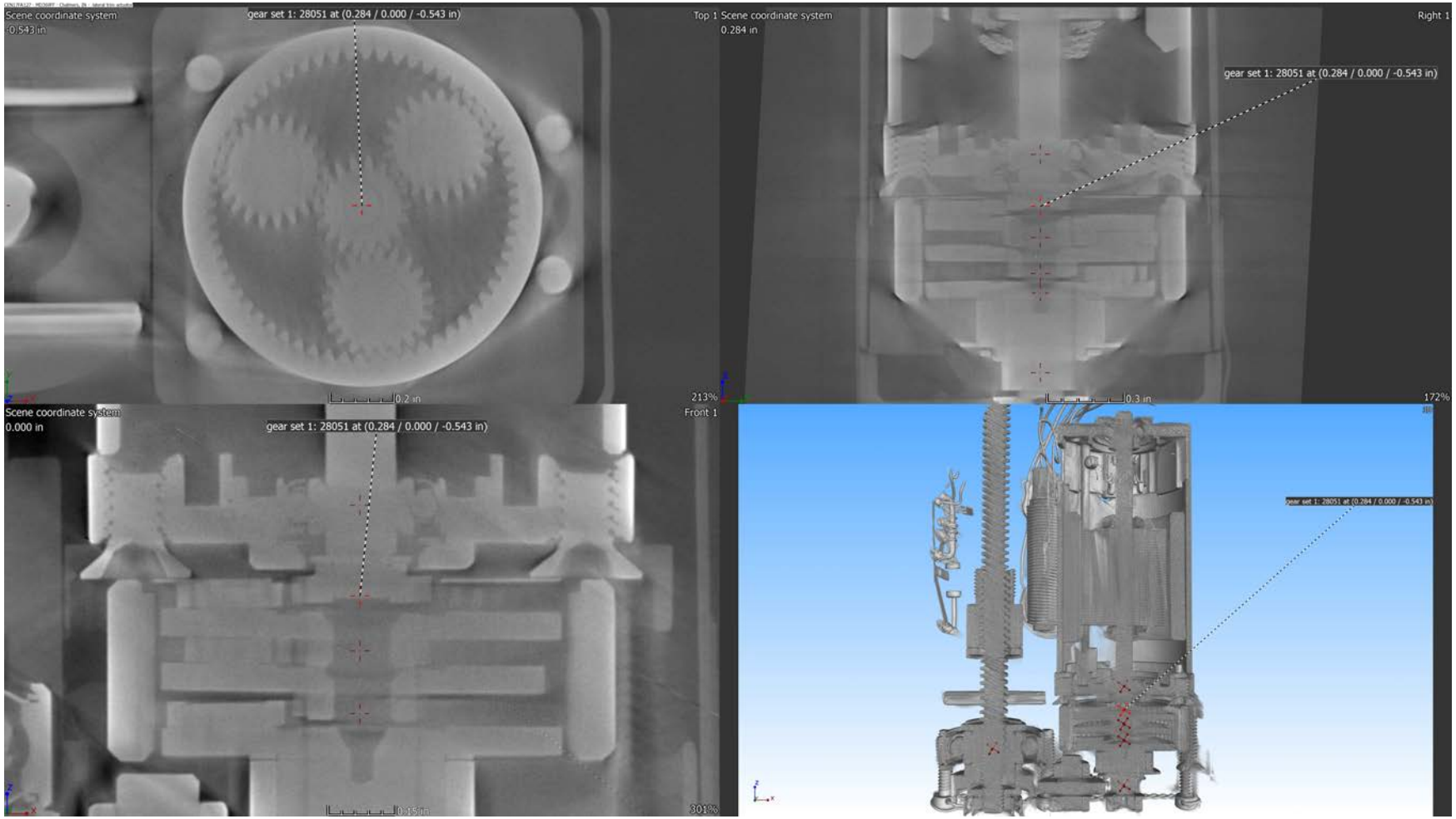

Figure 55
Lateral trim actuator – gear set 1

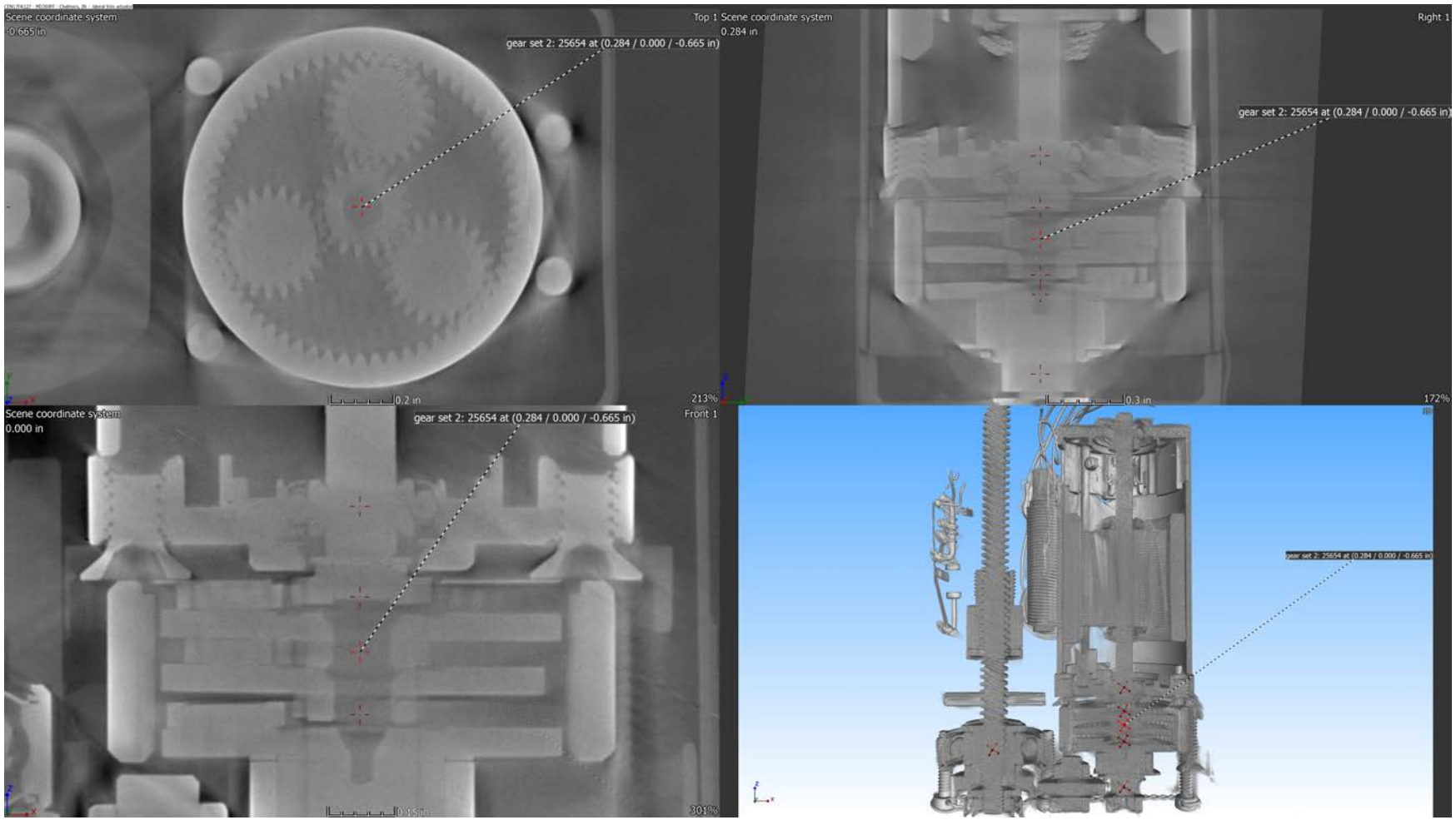

Figure 56
Lateral trim actuator – gear set 2

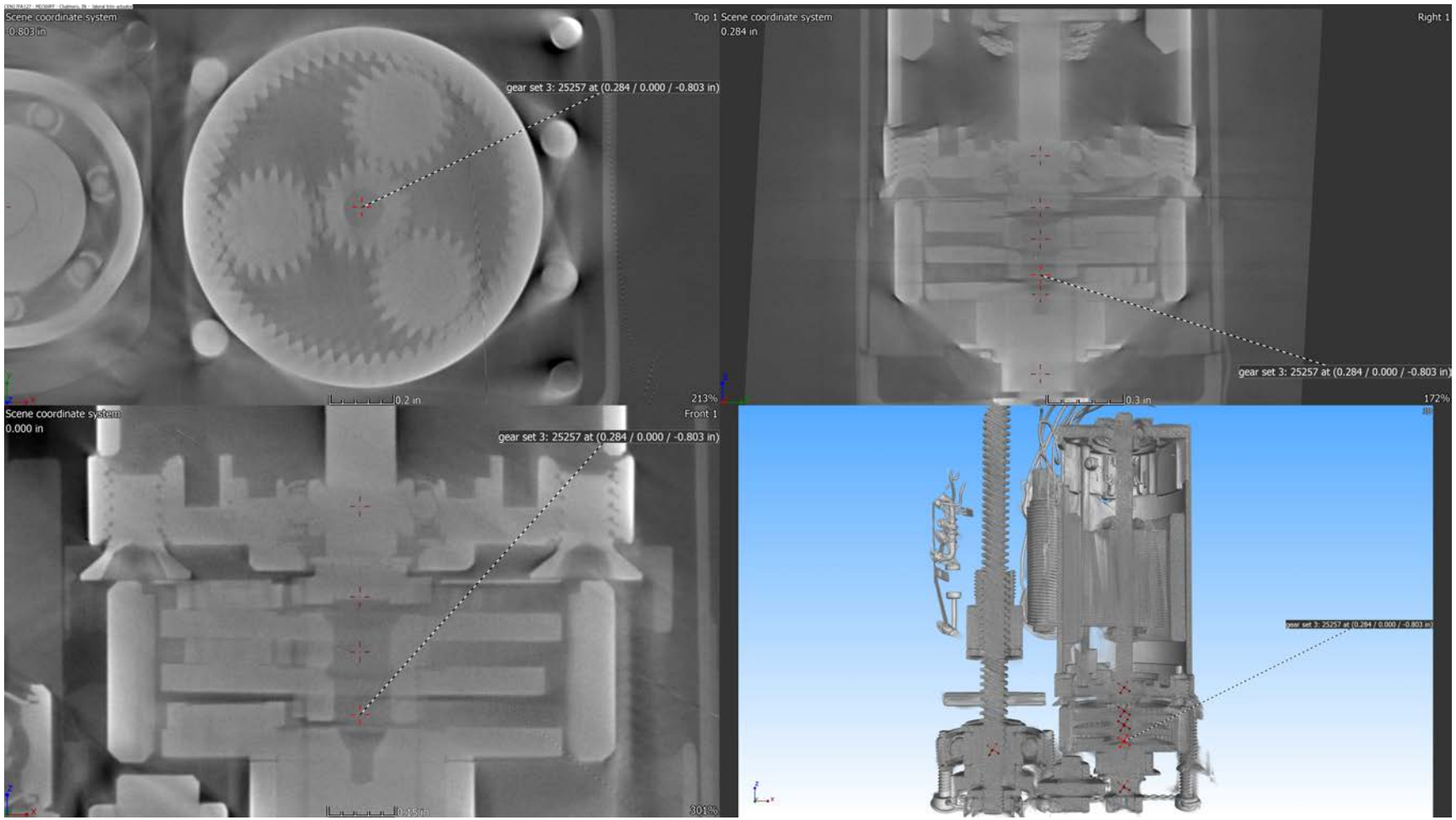

Figure 57
Lateral trim actuator – gear set 3

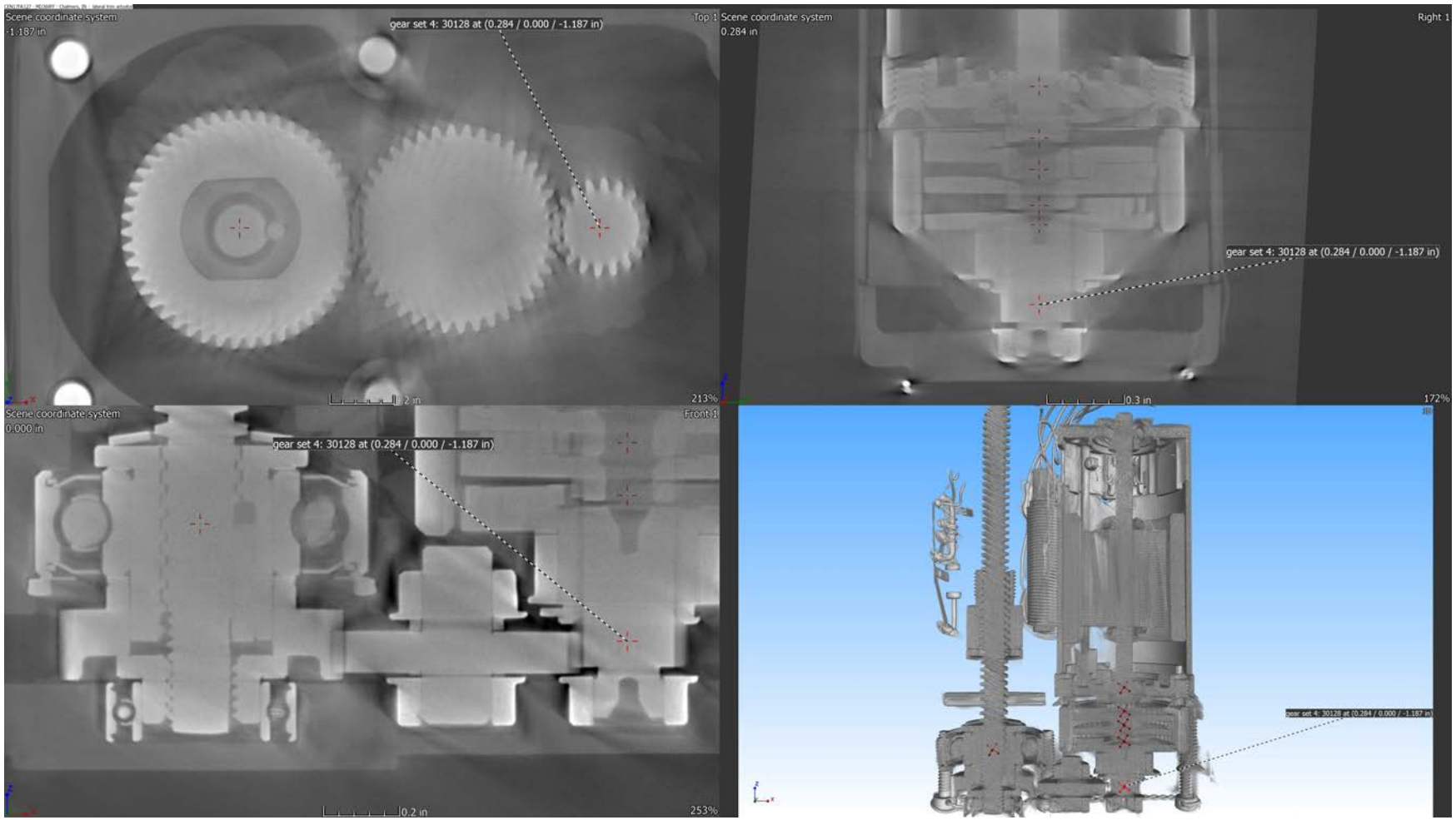

Figure 58
Lateral trim actuator – gear set 4

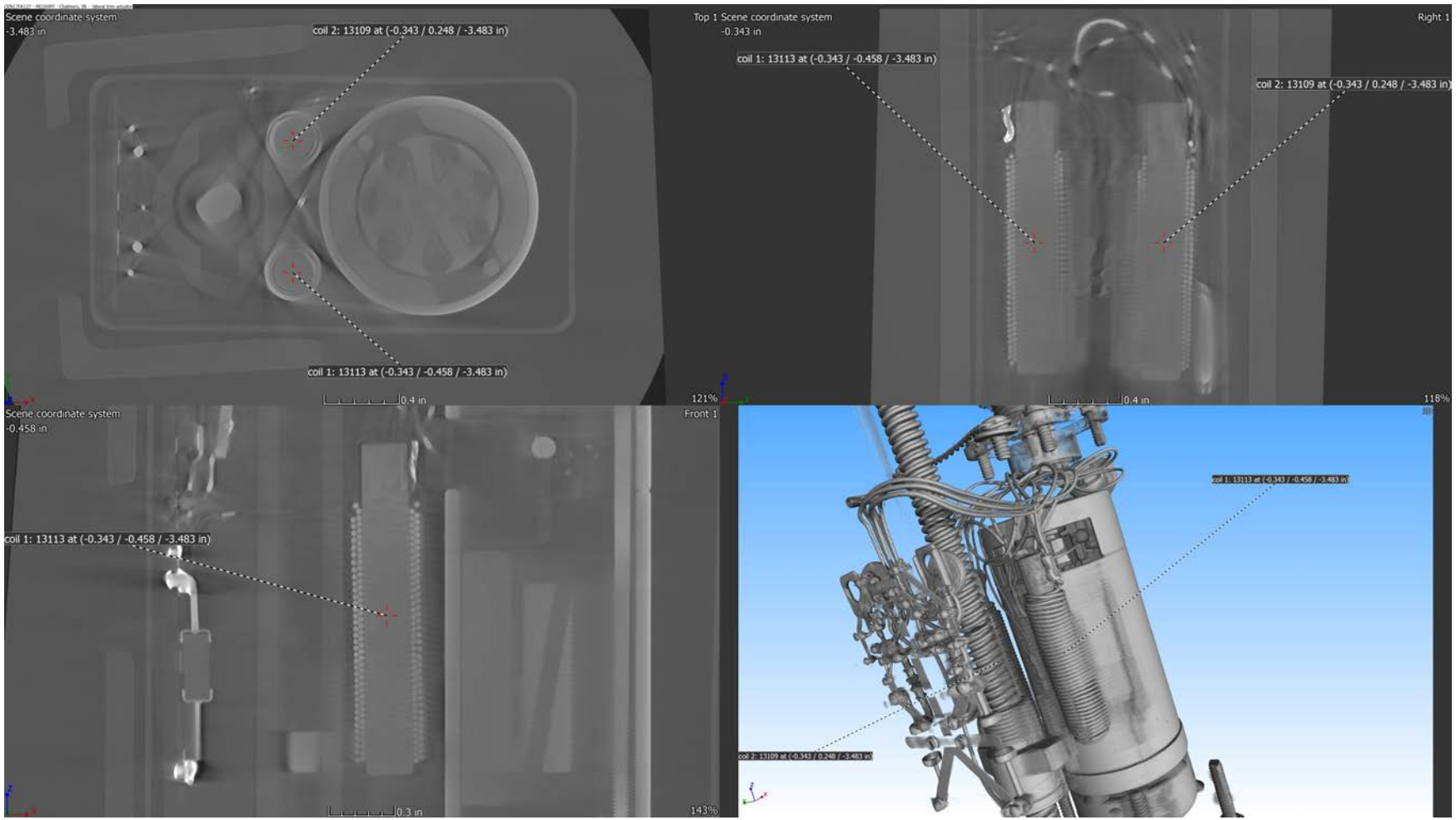

Figure 59
Lateral trim actuator – coil 1

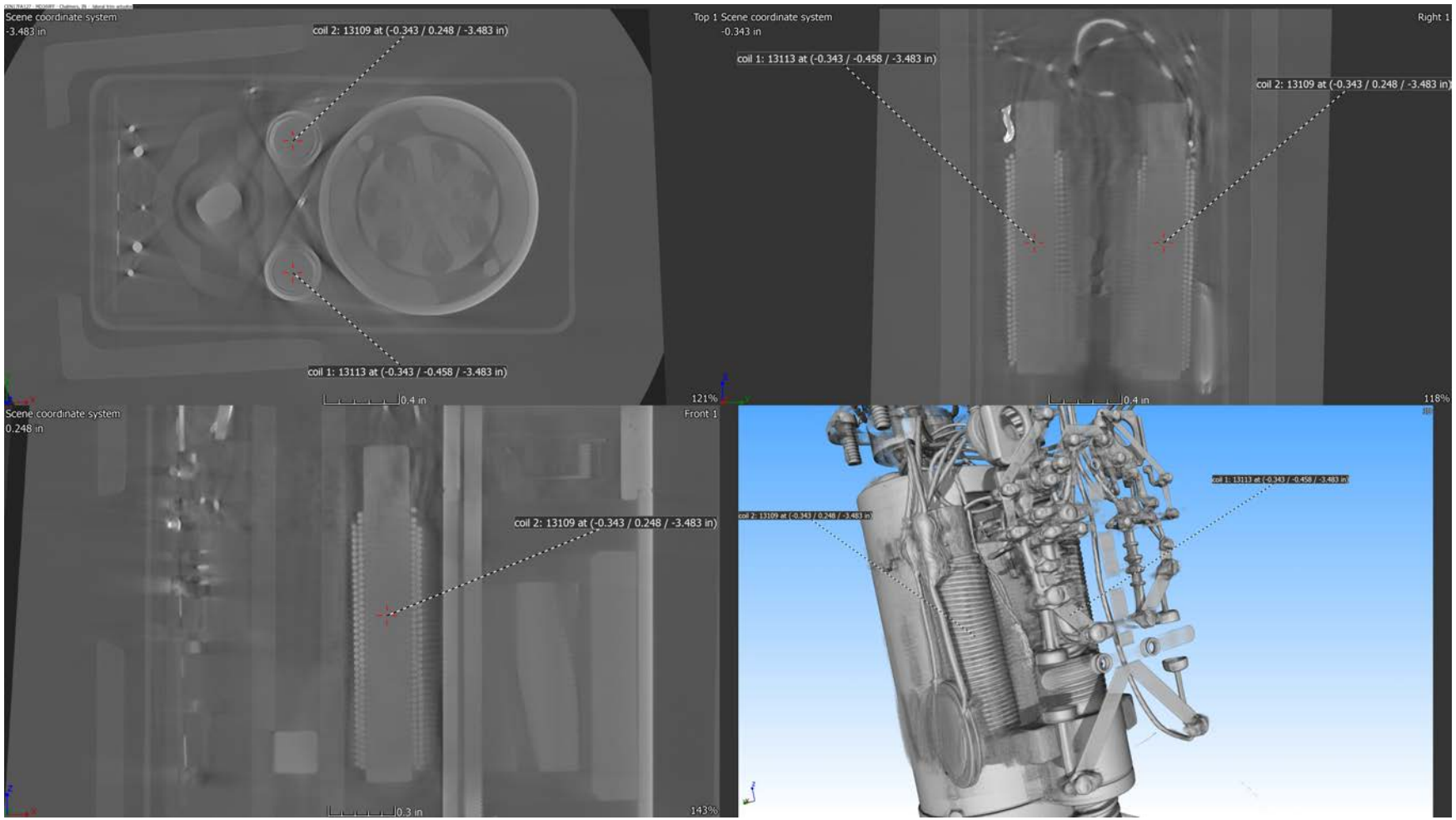

Figure 60
Lateral trim actuator – coil 2

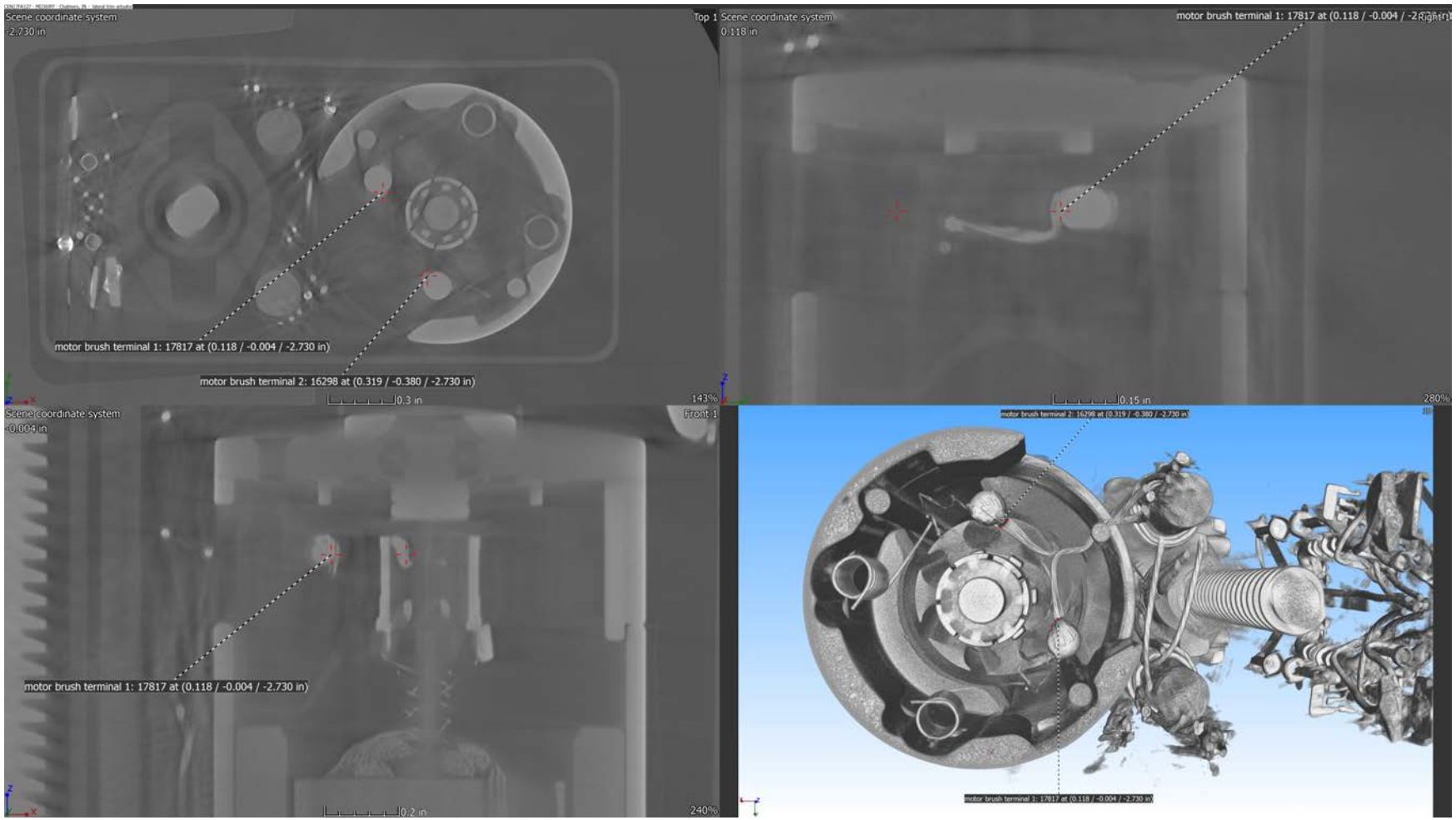

Figure 61
Lateral trim actuator – motor brush terminal 1

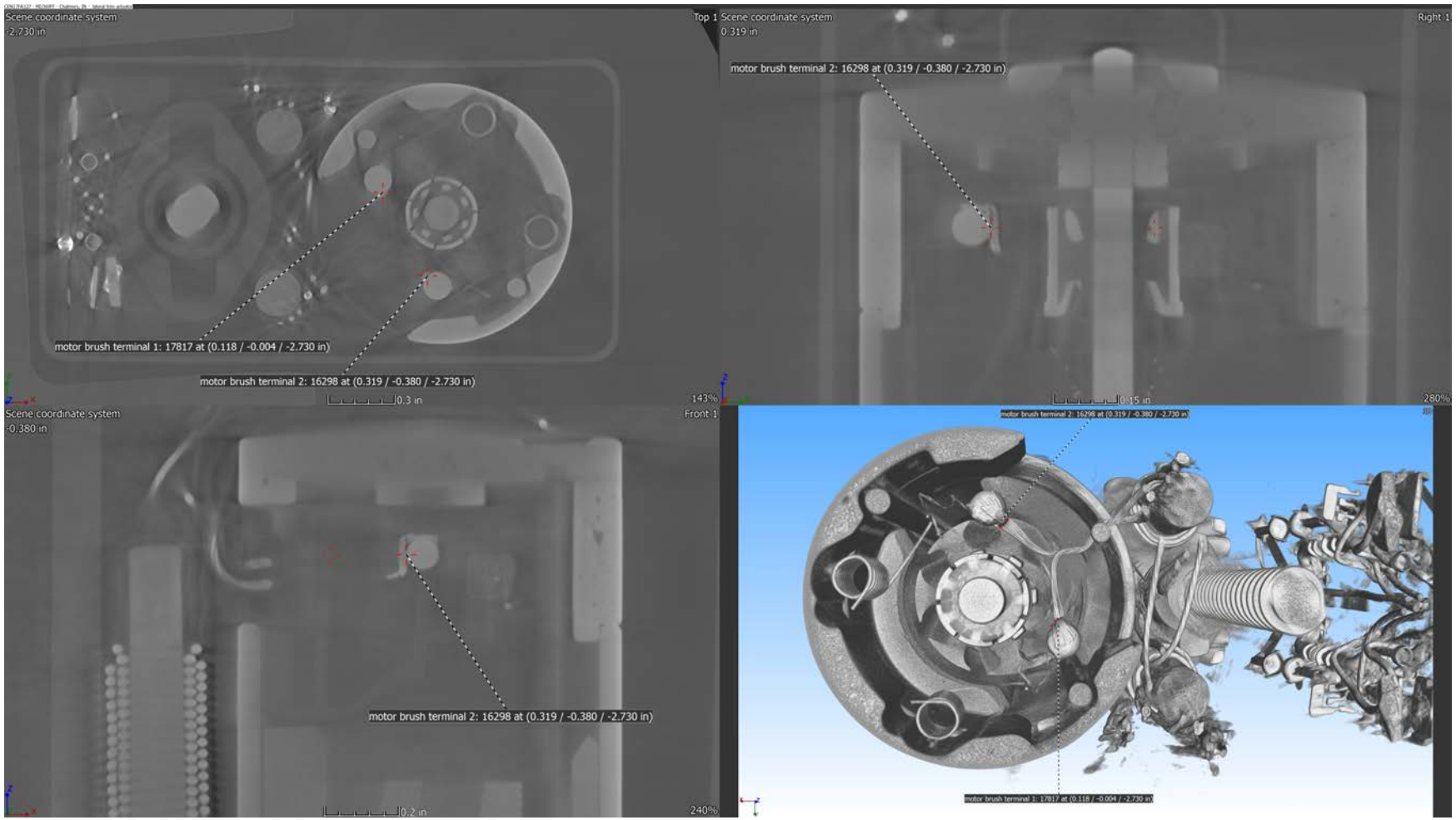

Figure 62
Lateral trim actuator – motor brush terminal 2

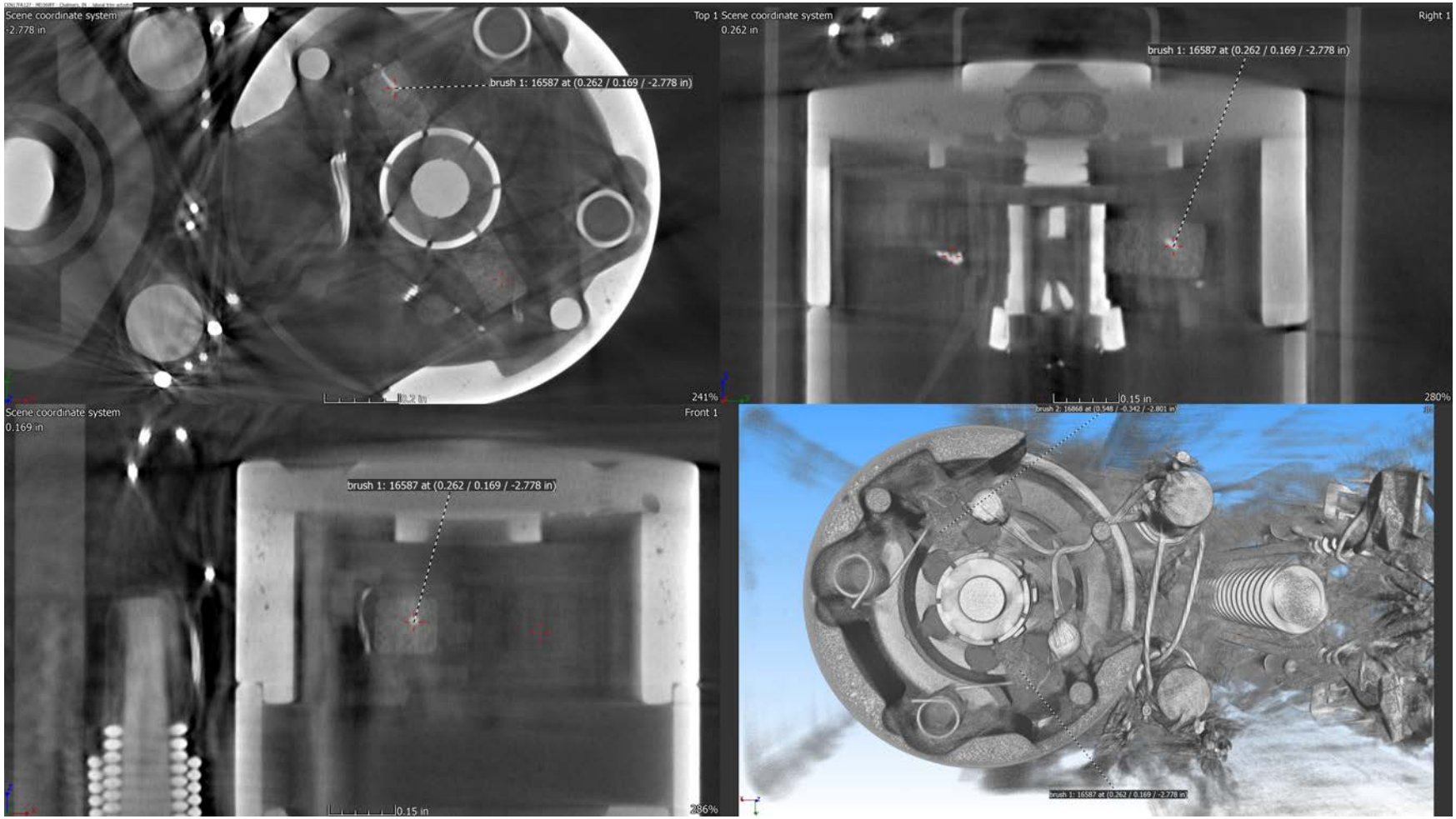

Figure 63
Lateral trim actuator – brush 1

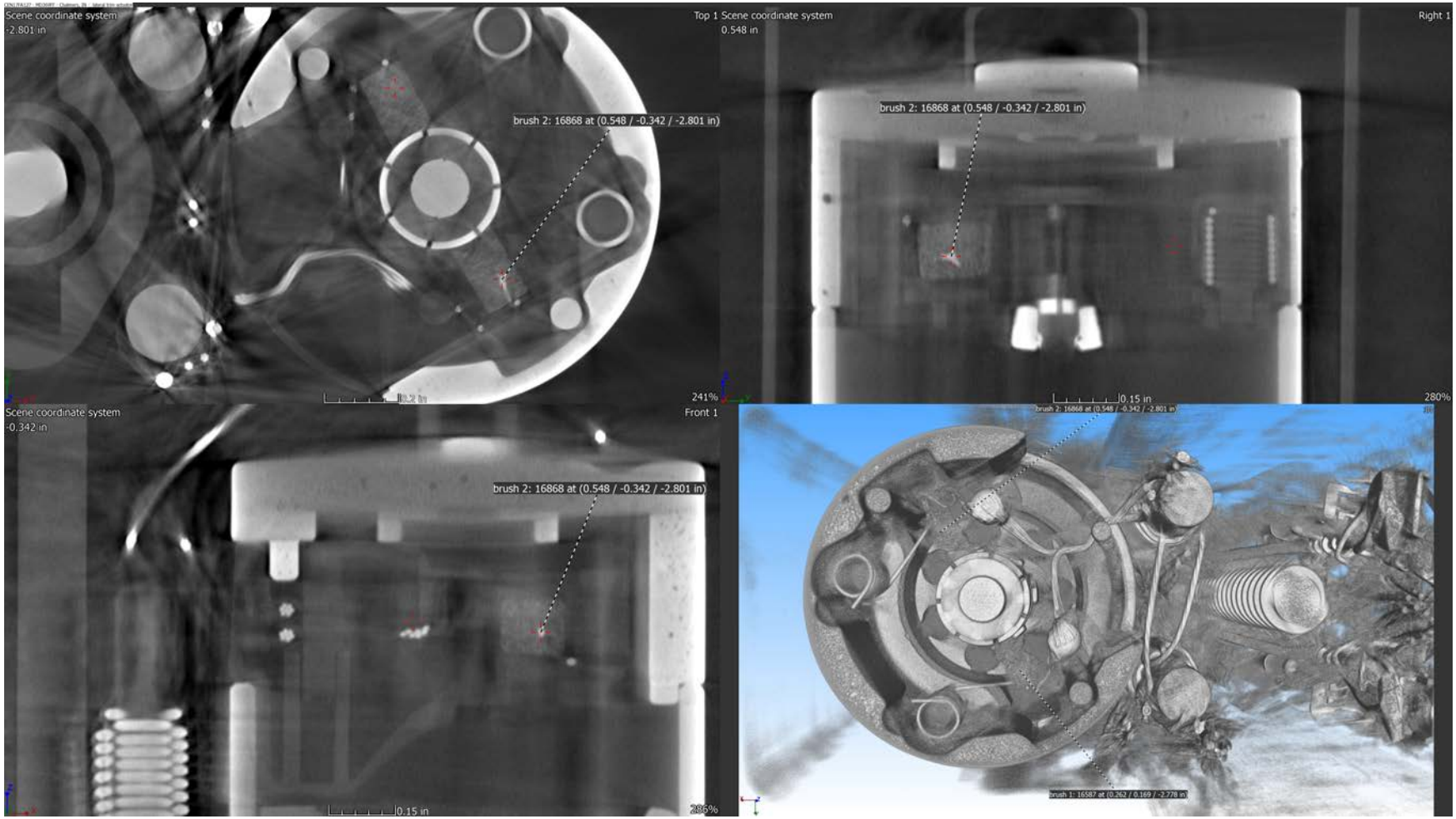

Figure 64
Lateral trim actuator – brush 2

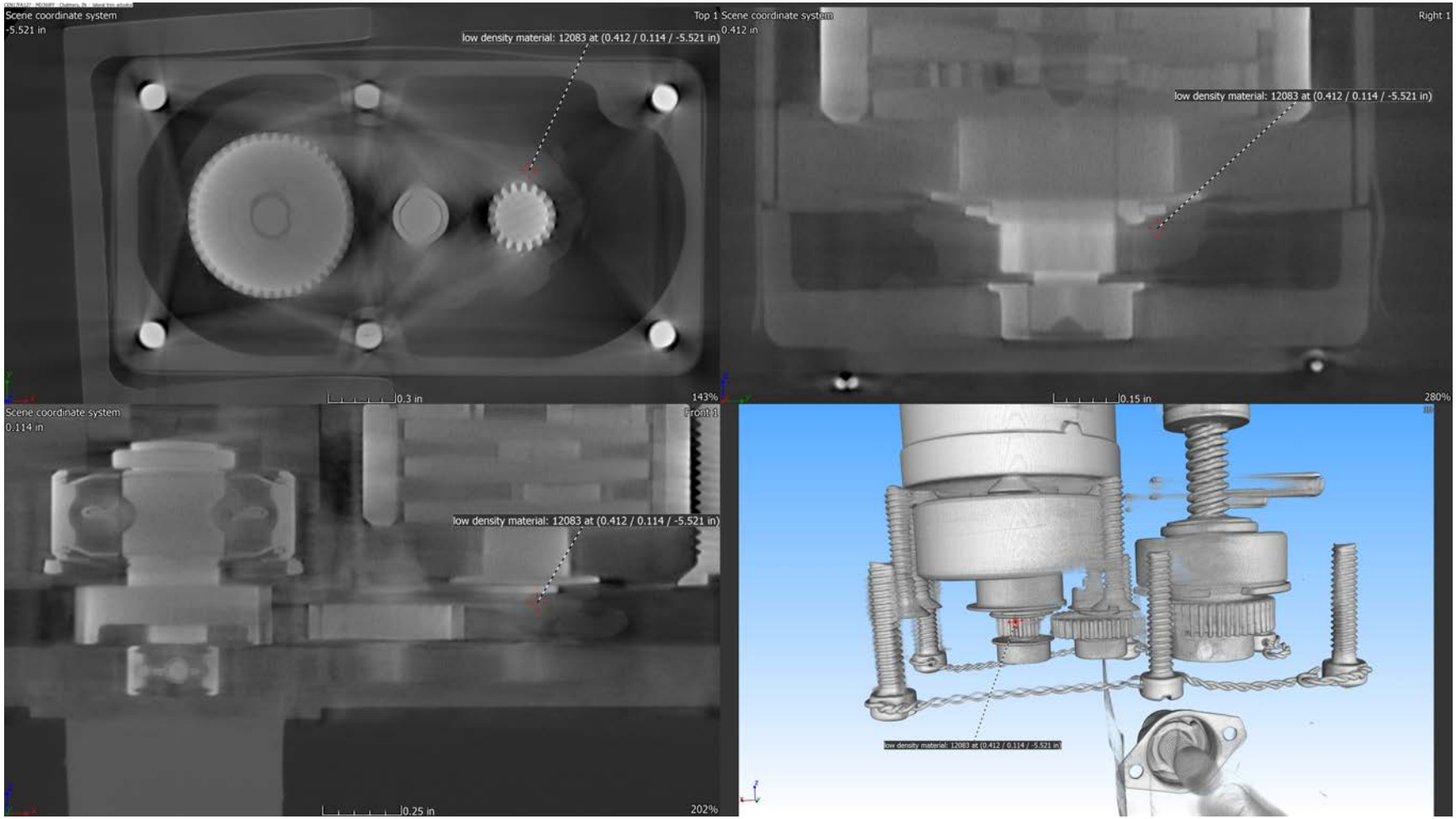

Figure 65
Lateral trim actuator – low density material

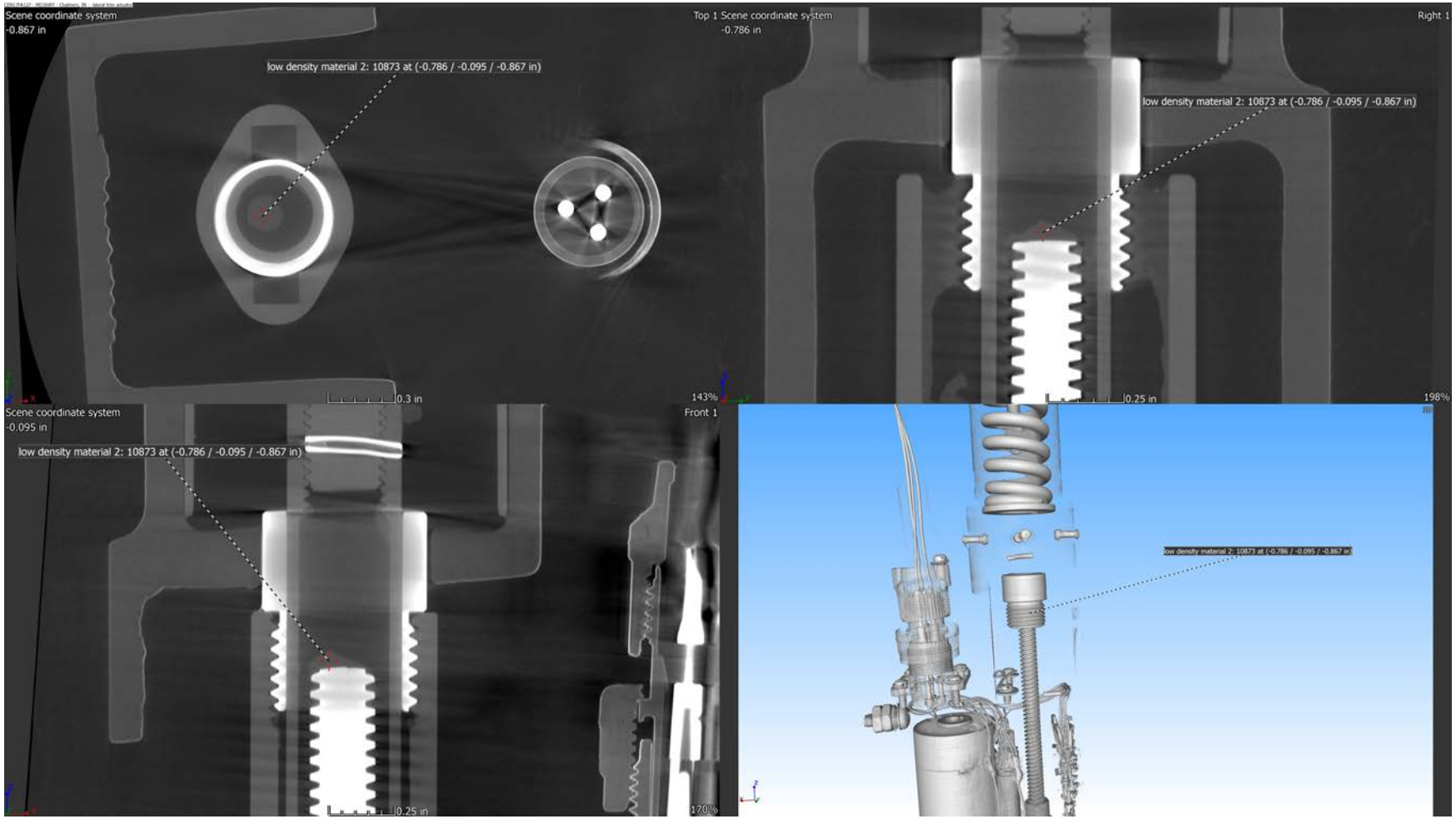

Figure 66
Lateral trim actuator – low density material 2

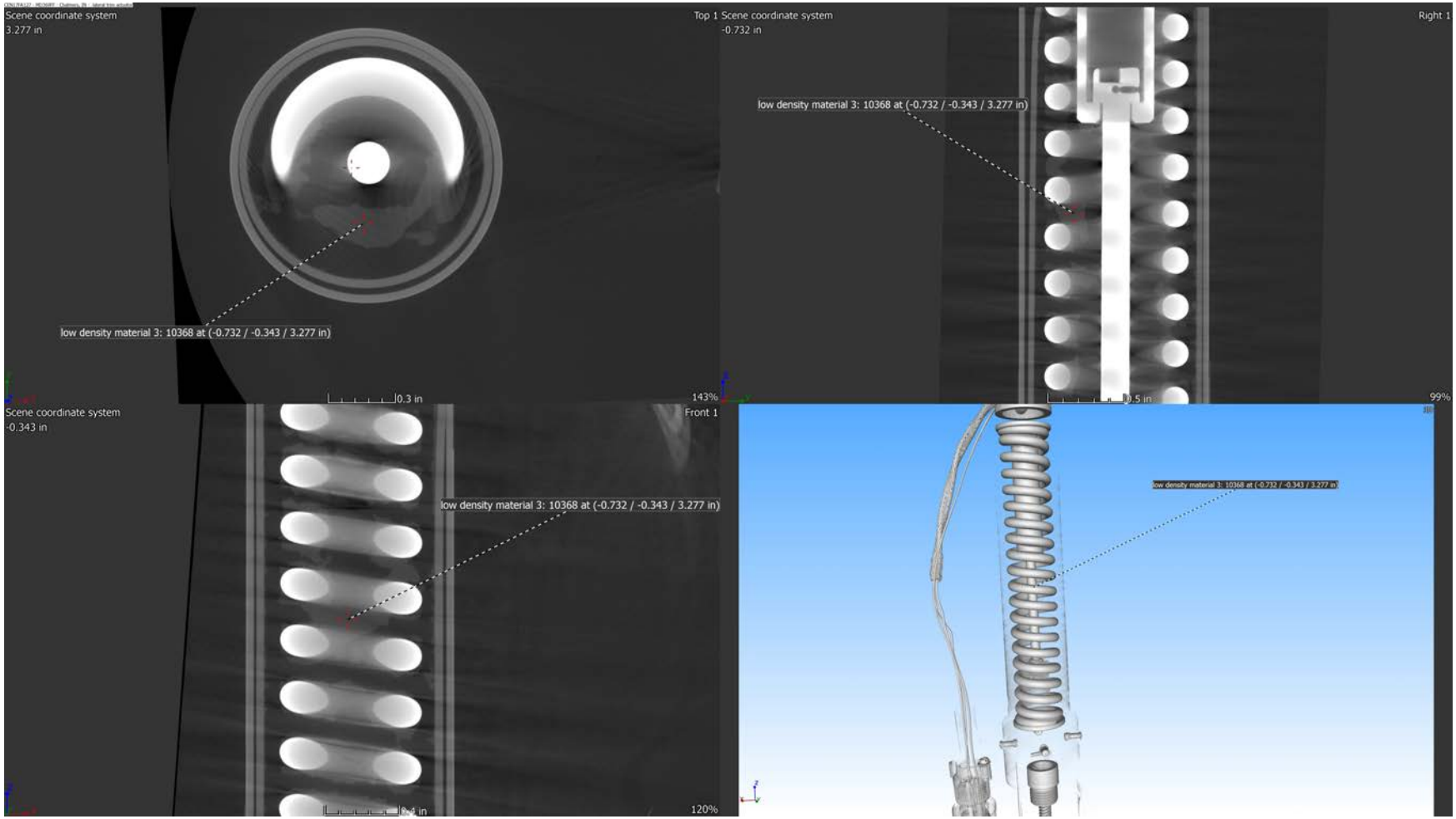

Figure 67
Lateral trim actuator – low density material 3

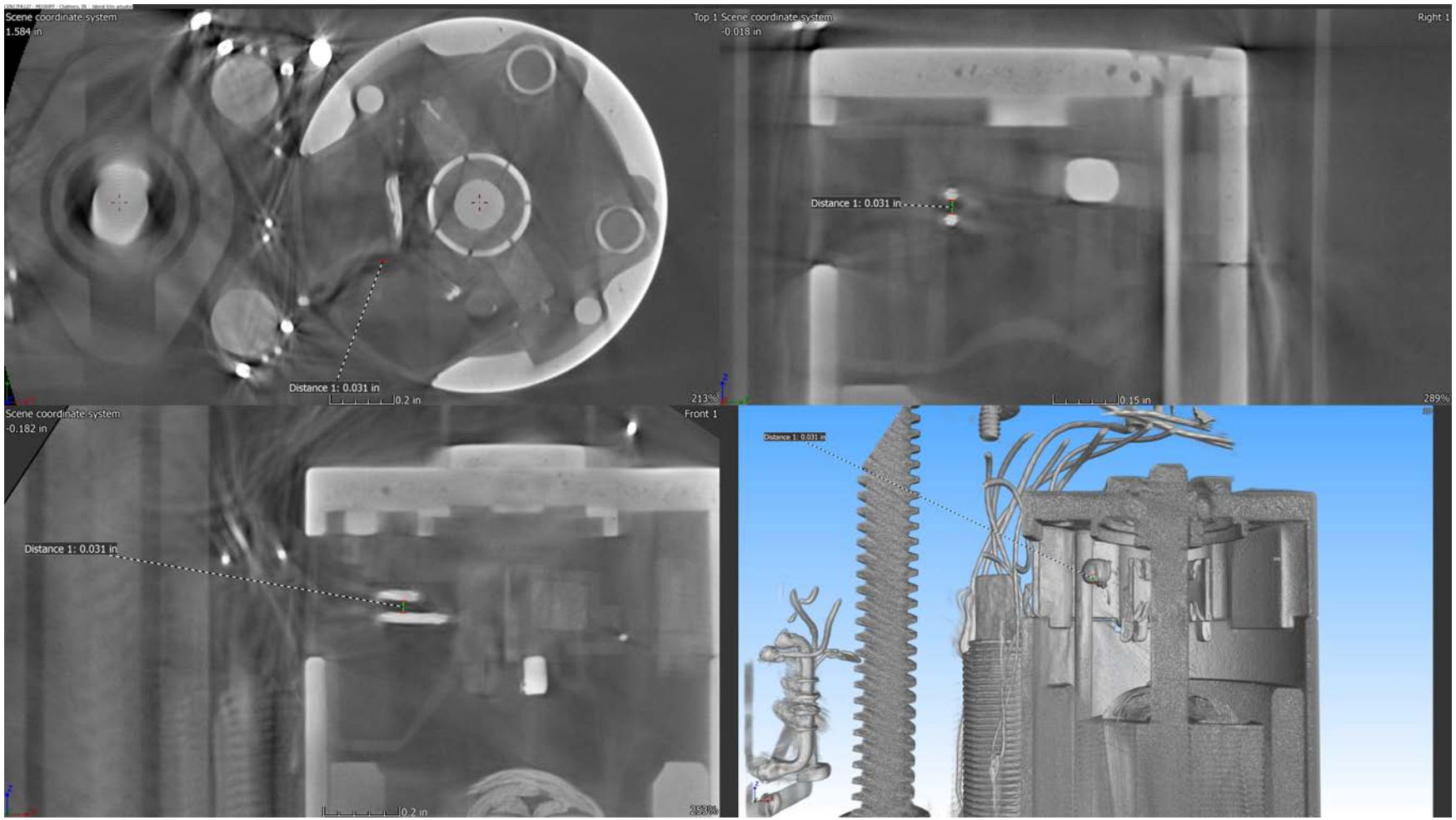

Figure 68
Lateral trim actuator – wire 2 to wire 3 clearance

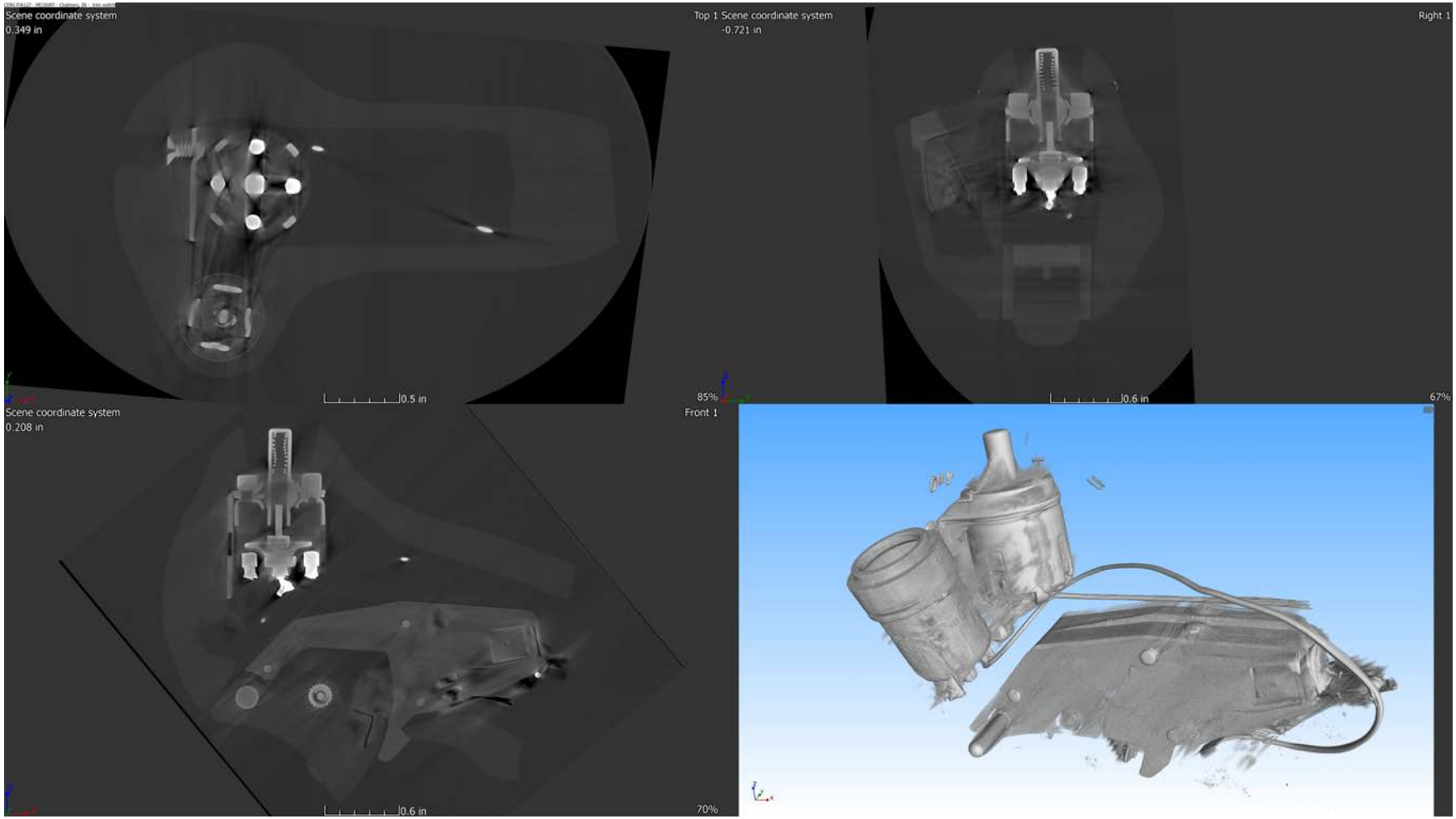

Figure 69
Cyclic grip and trim switch - overview

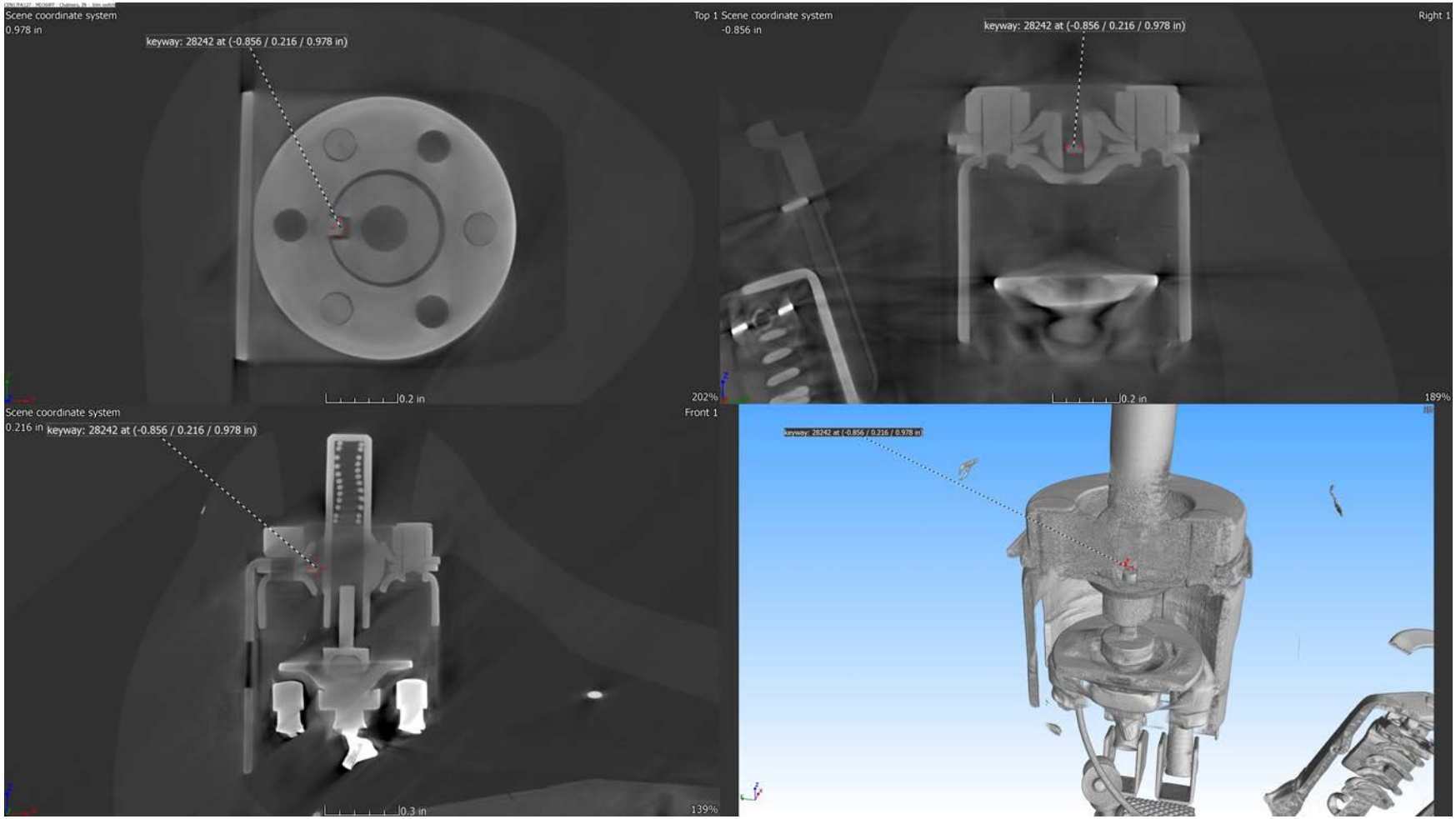

Figure 70
Trim switch - keyway

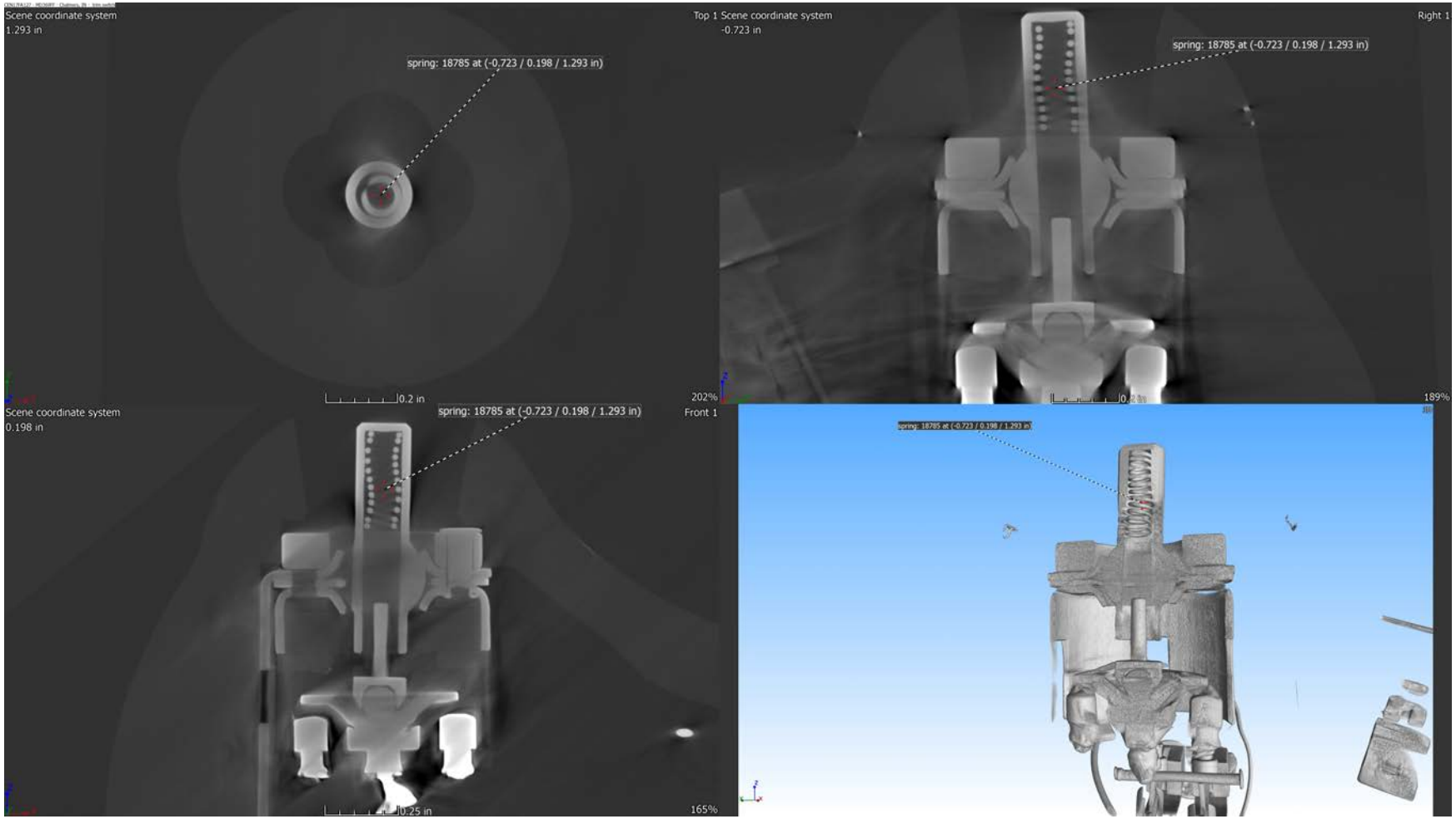

Figure 71
Trim switch - spring

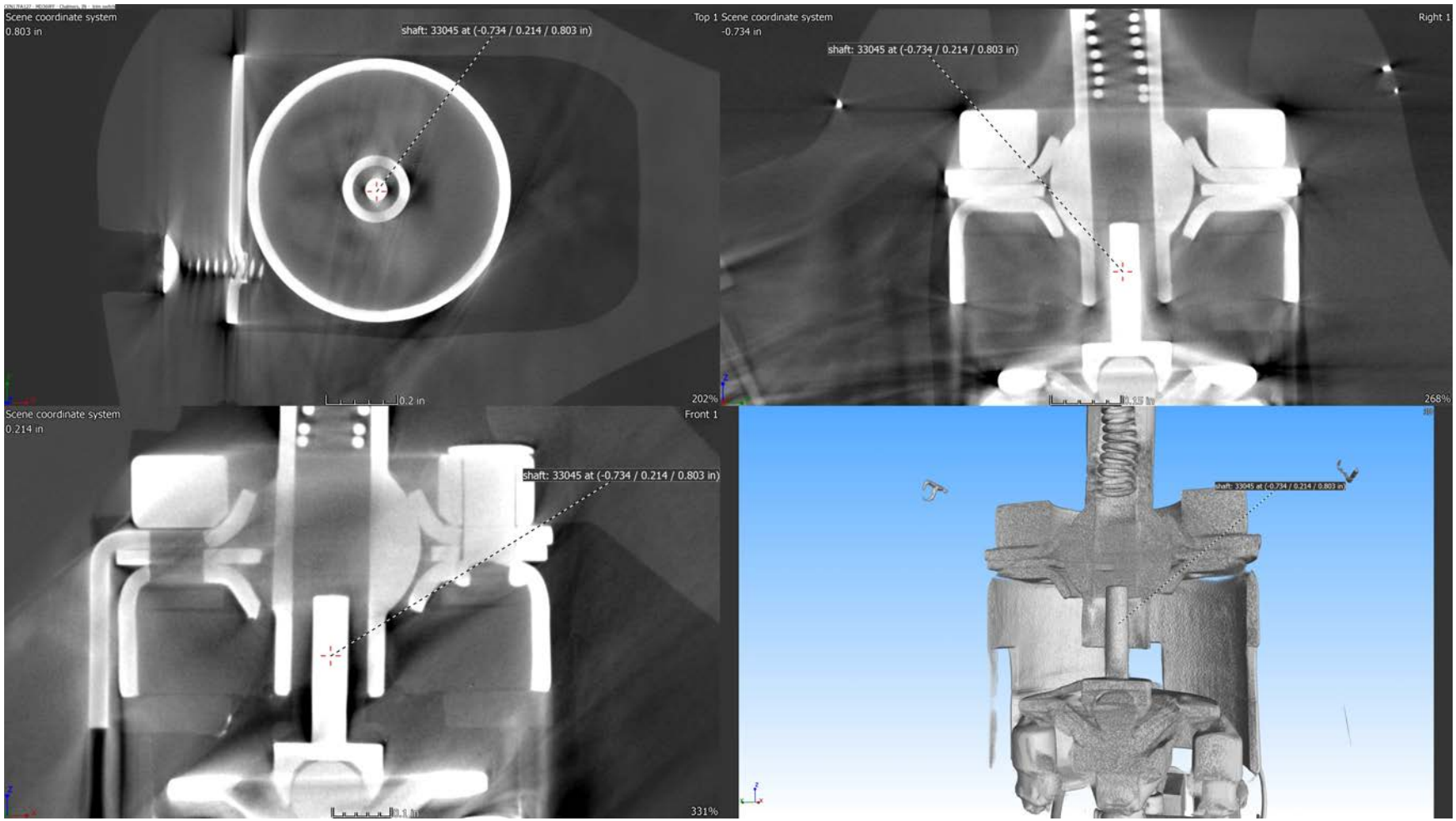

Figure 72
Trim switch - shaft

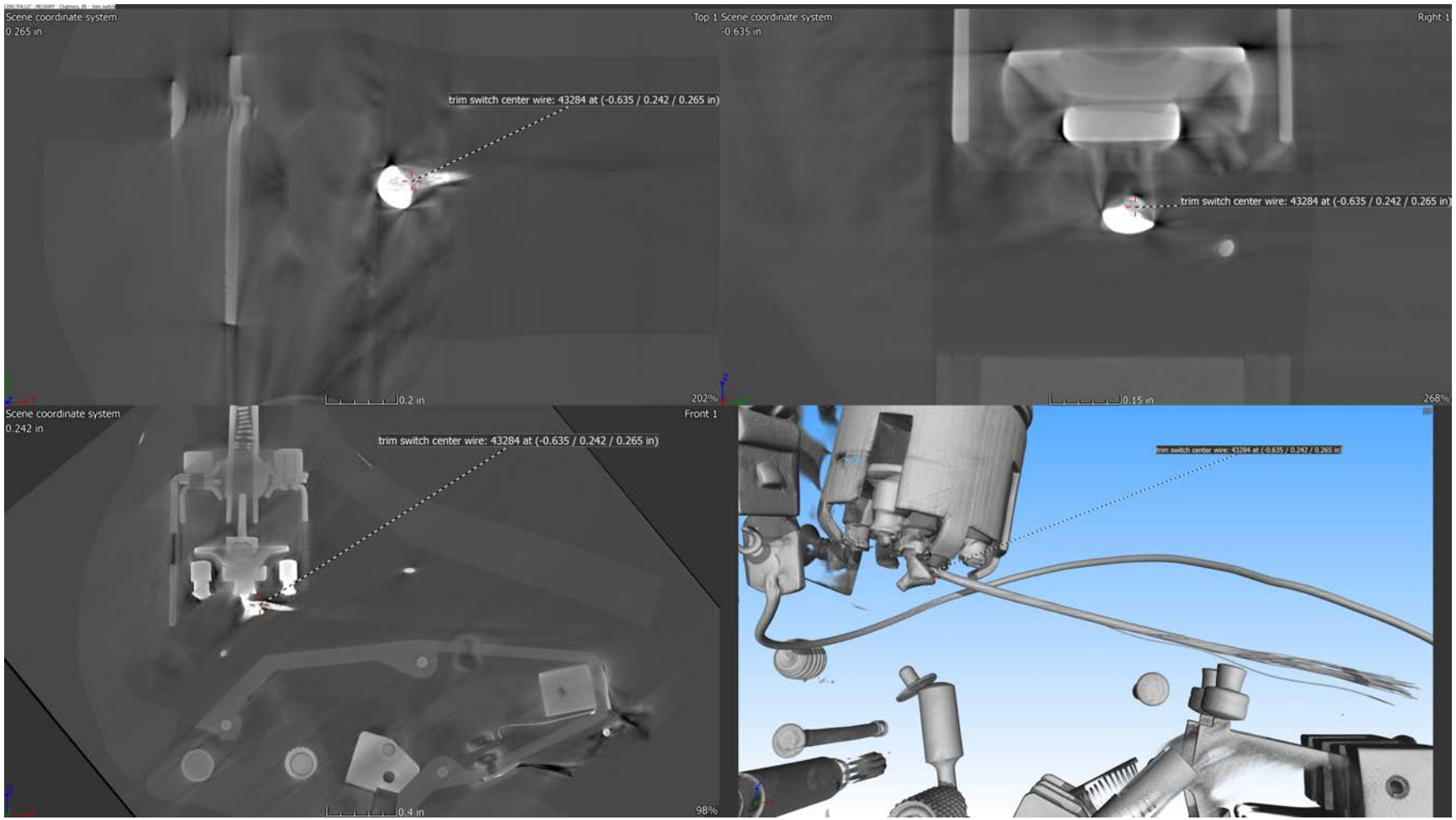

Figure 73
Trim switch – center wire

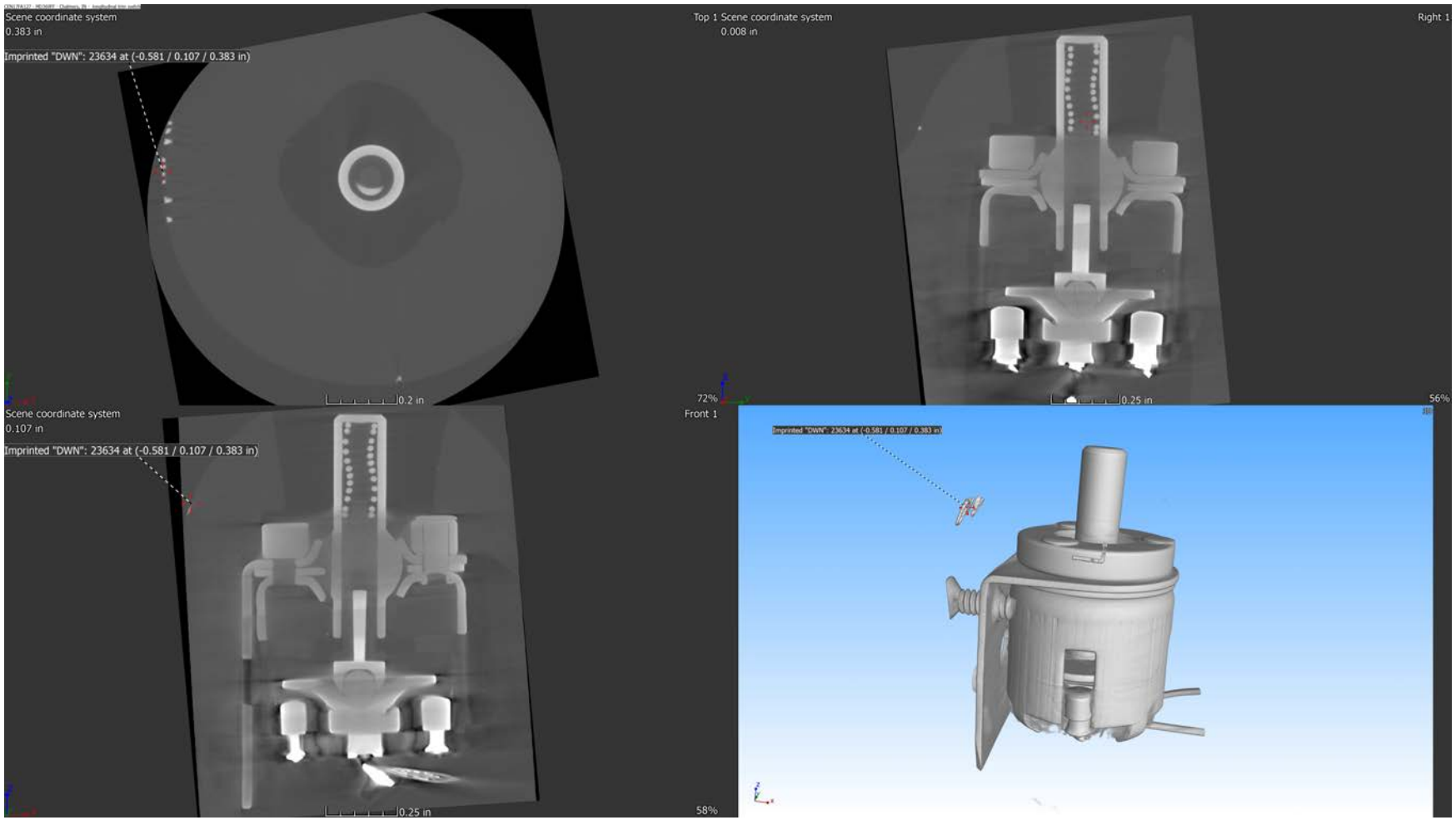

Figure 74
Trim switch – target CT - overview

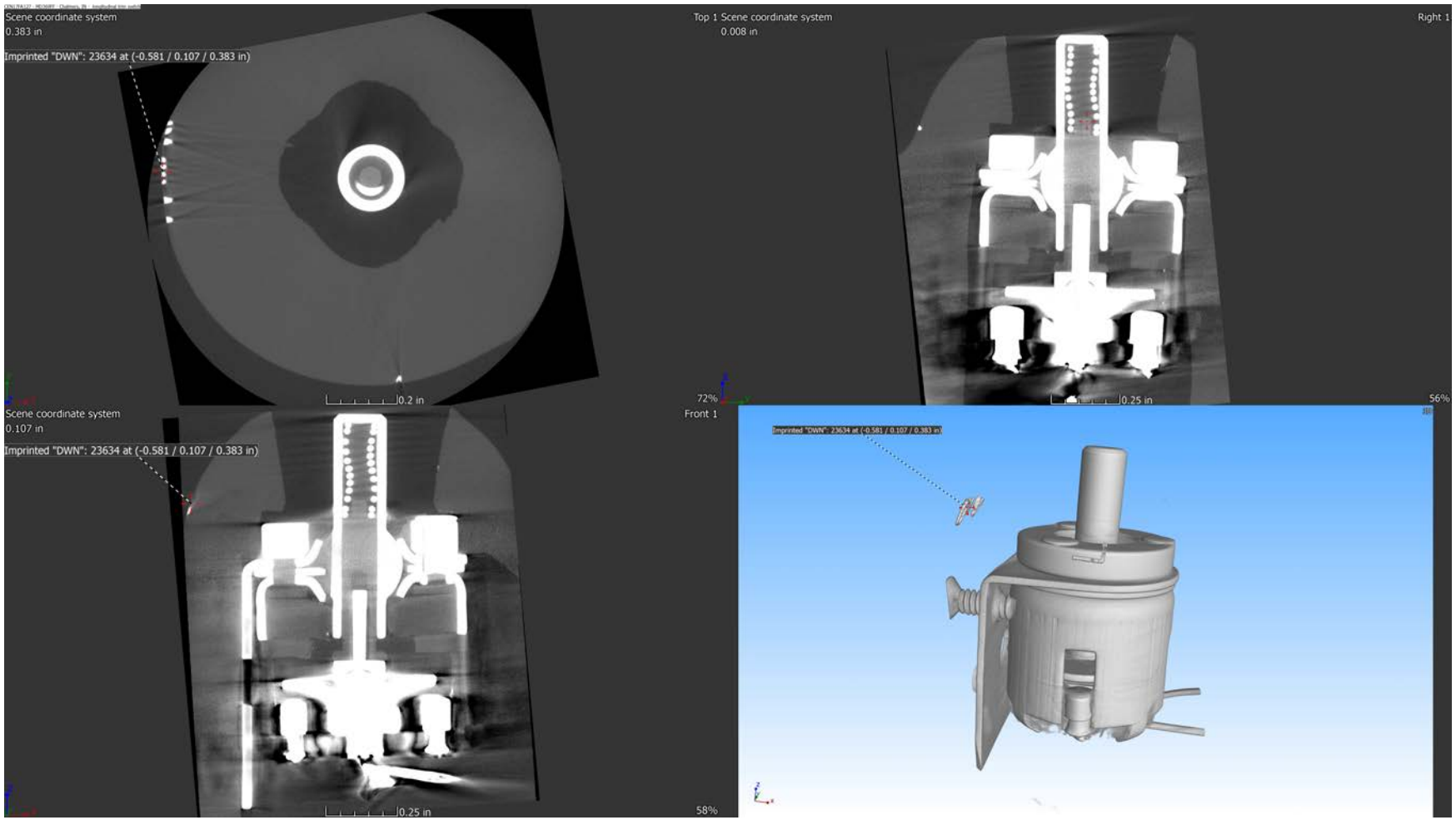

Figure 75
Trim switch – target CT – overview with enhanced contrast

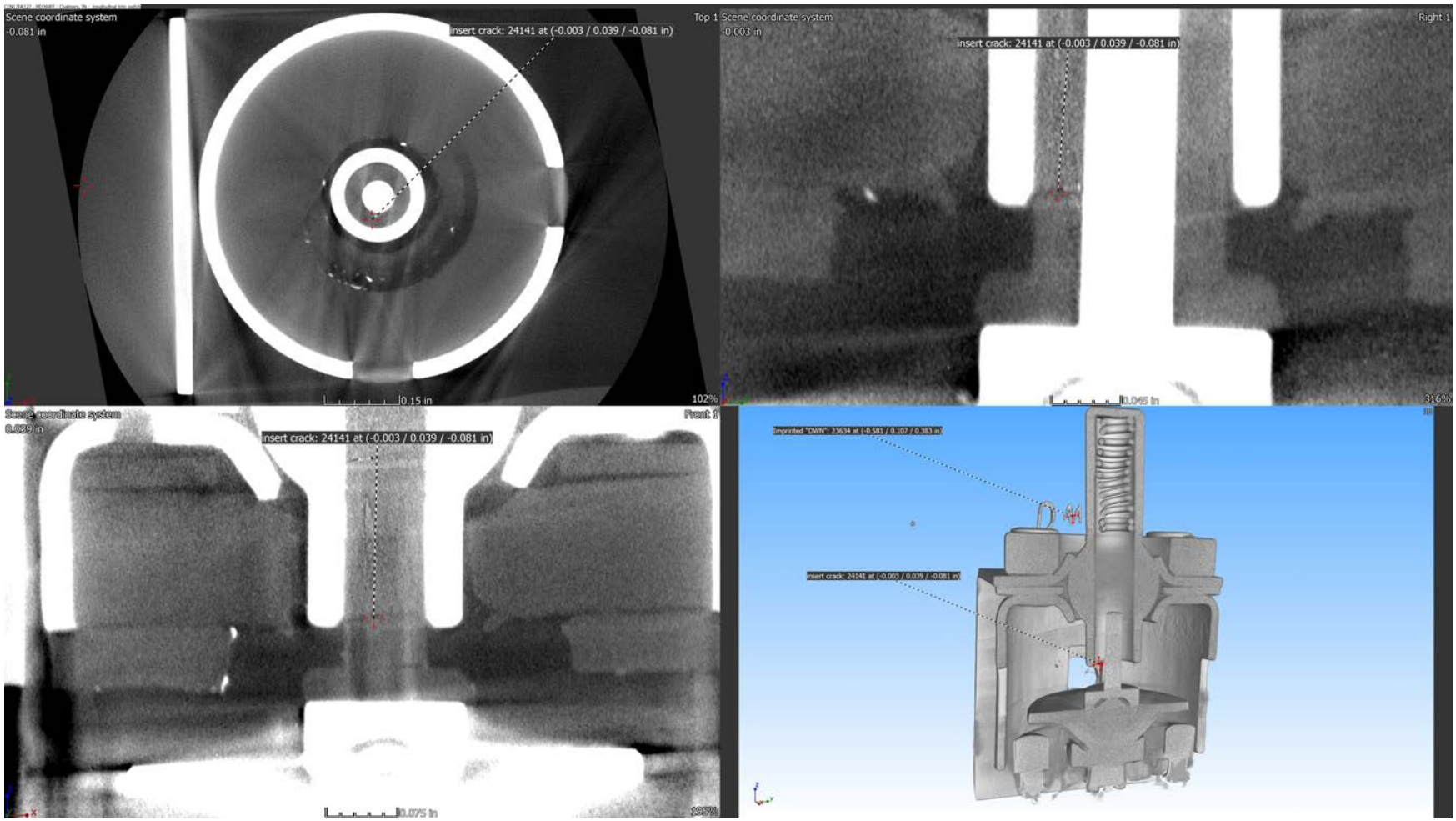

Figure 76
Trim switch – target CT – insert crack

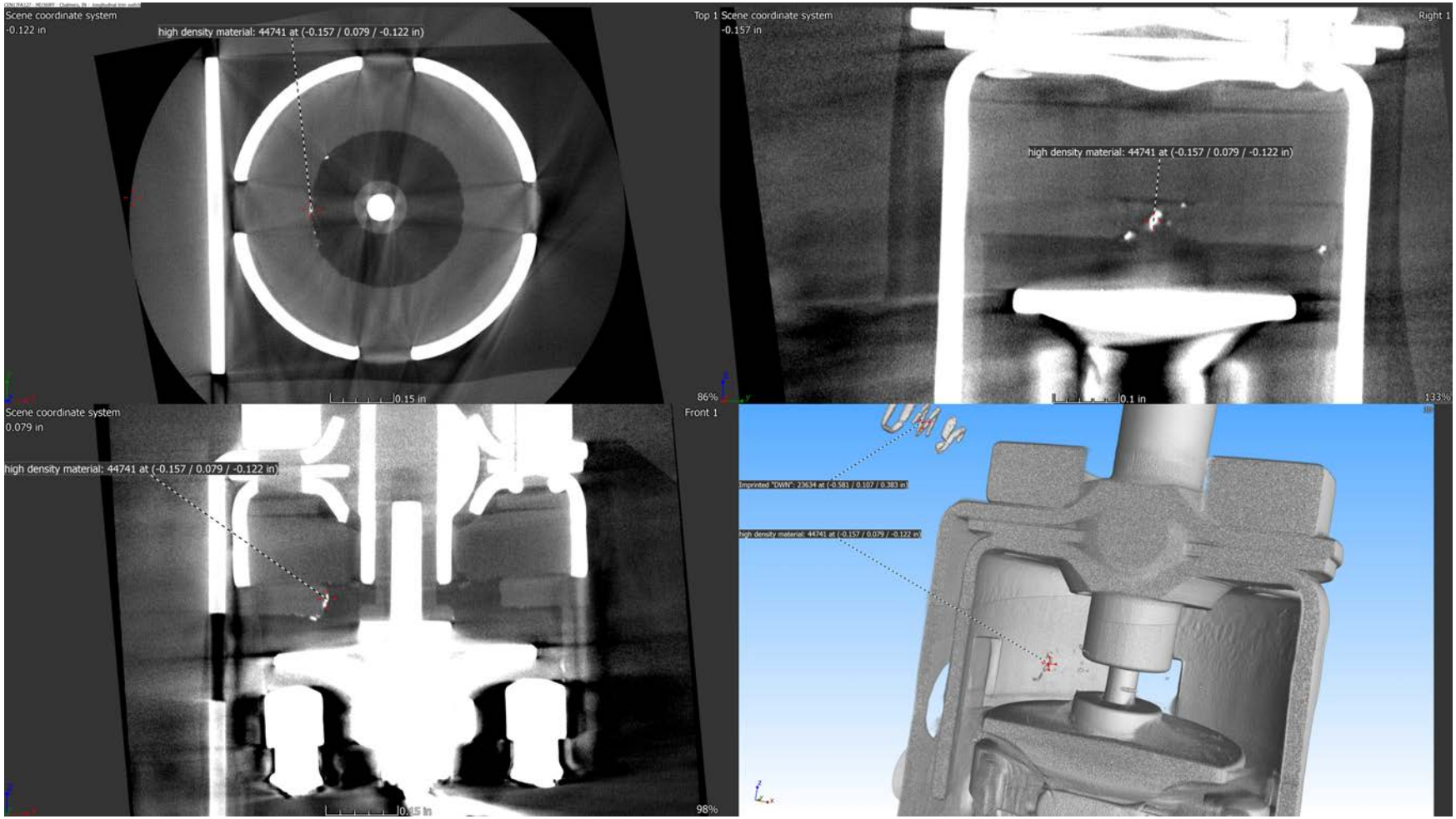

Figure 77
Trim switch – target CT – high density material

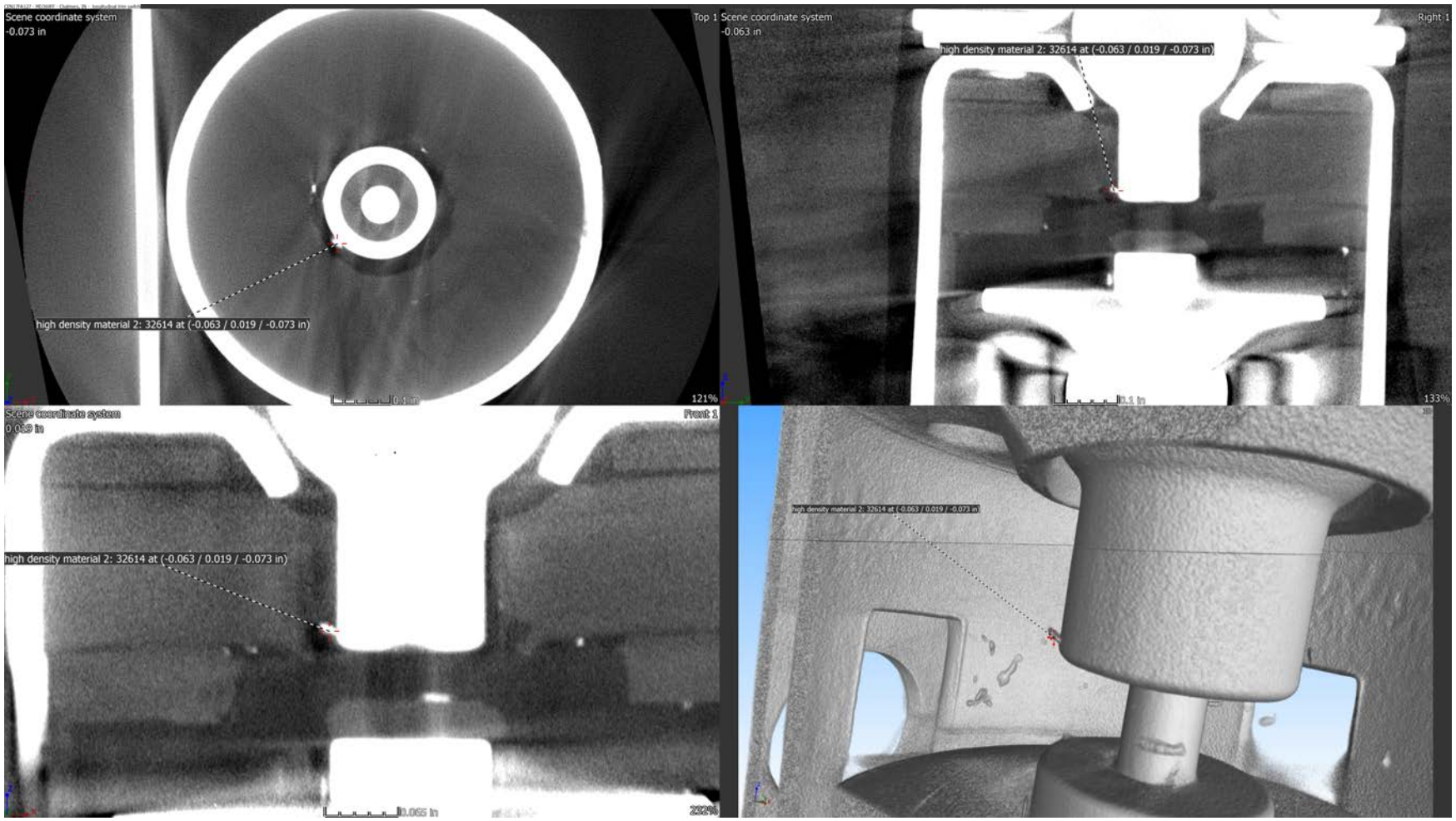

Figure 78
Trim switch – target CT – high density material 2

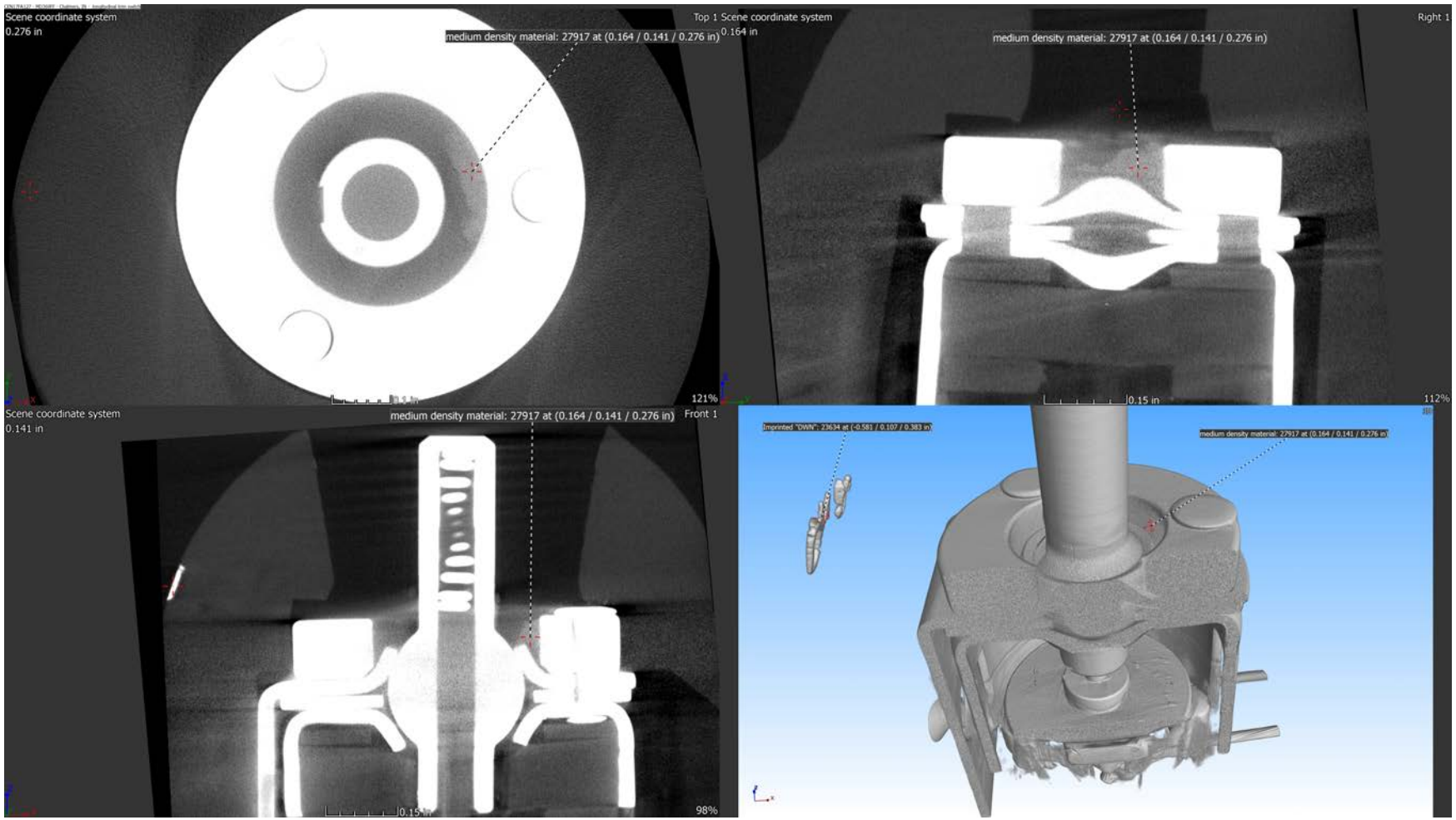

Figure 79
Trim switch – target CT – medium density material

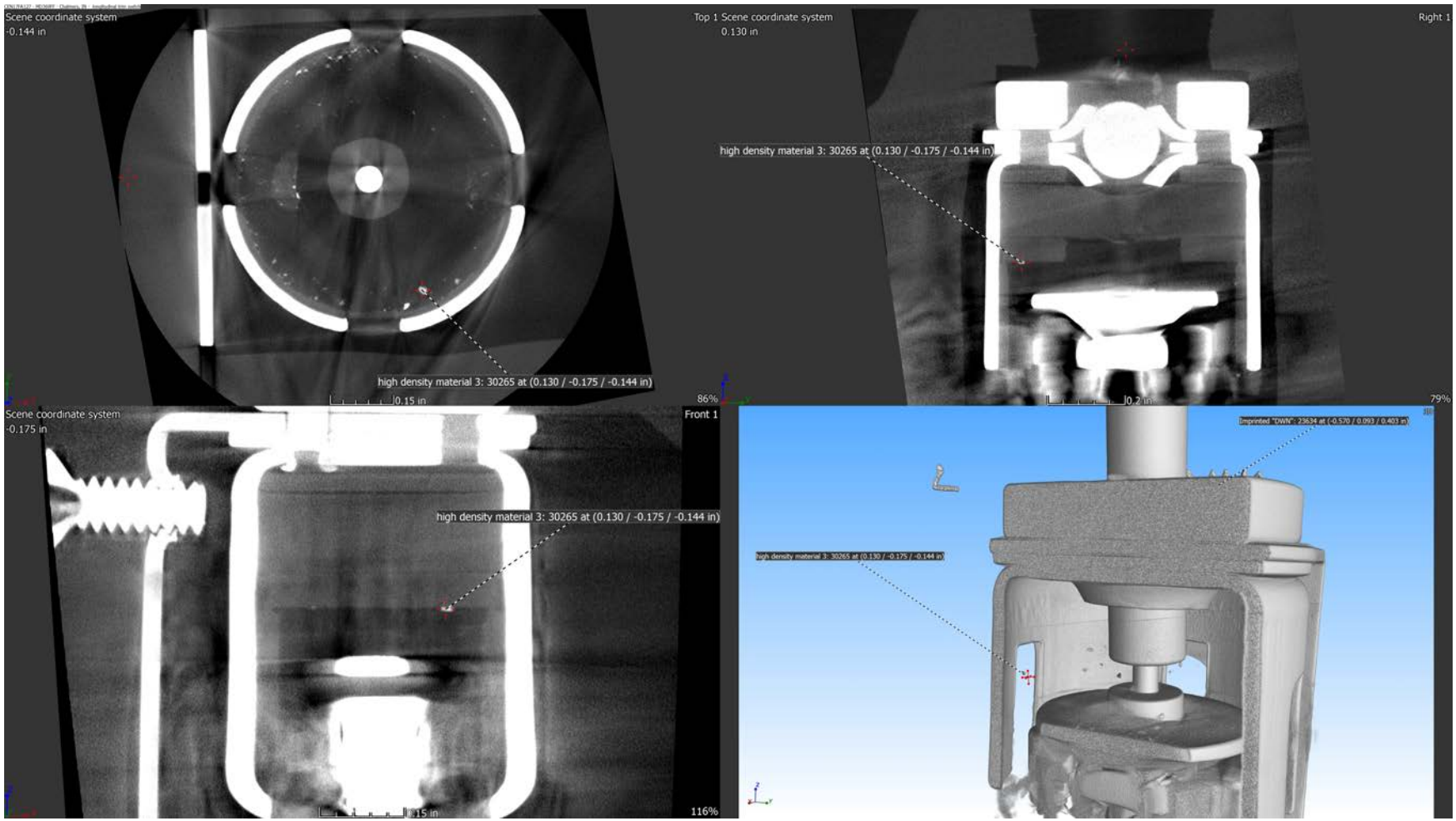

Figure 80
Trim switch – target CT – high density material 3

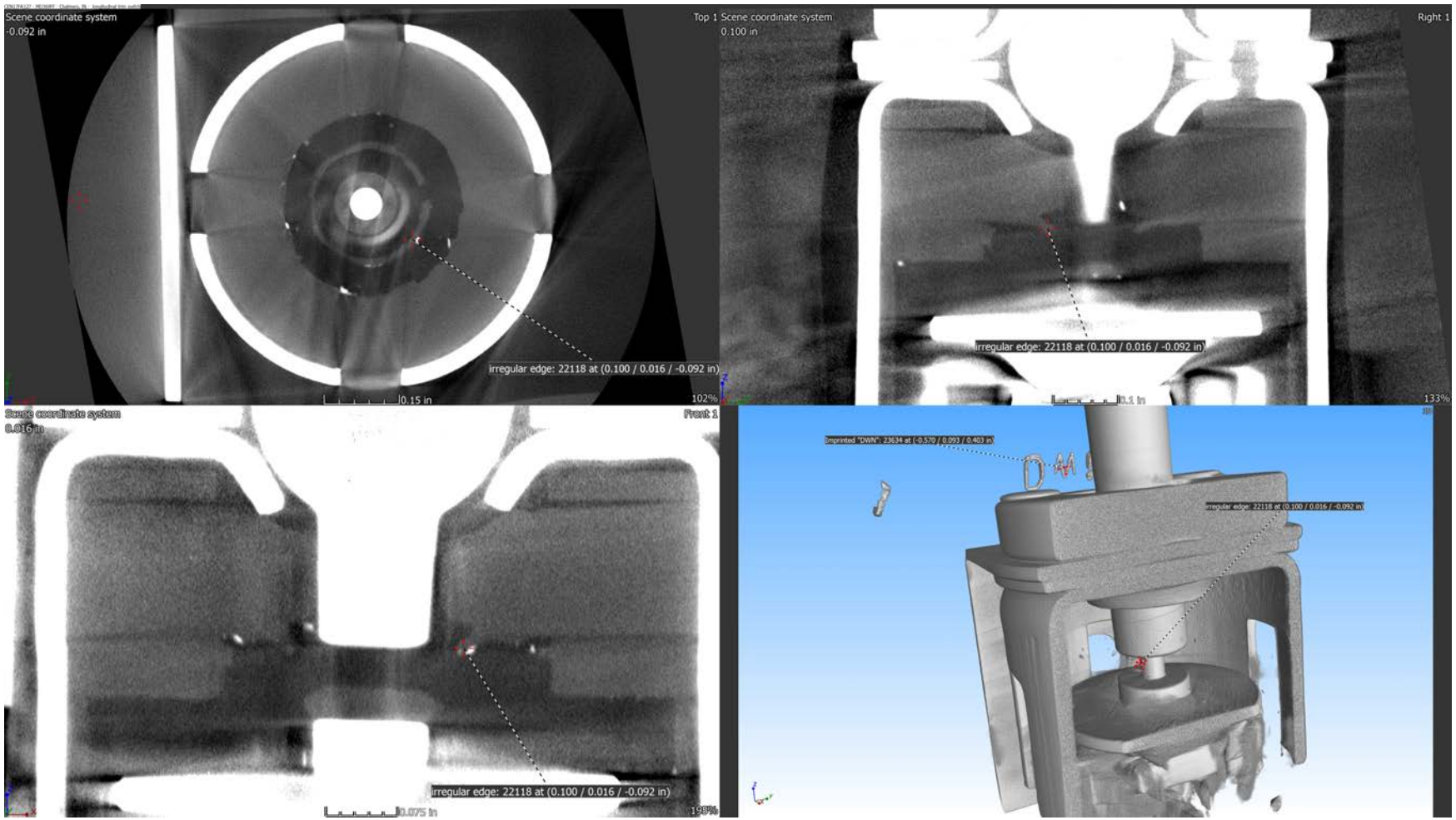

Figure 81
Trim switch – target CT – irregular edge

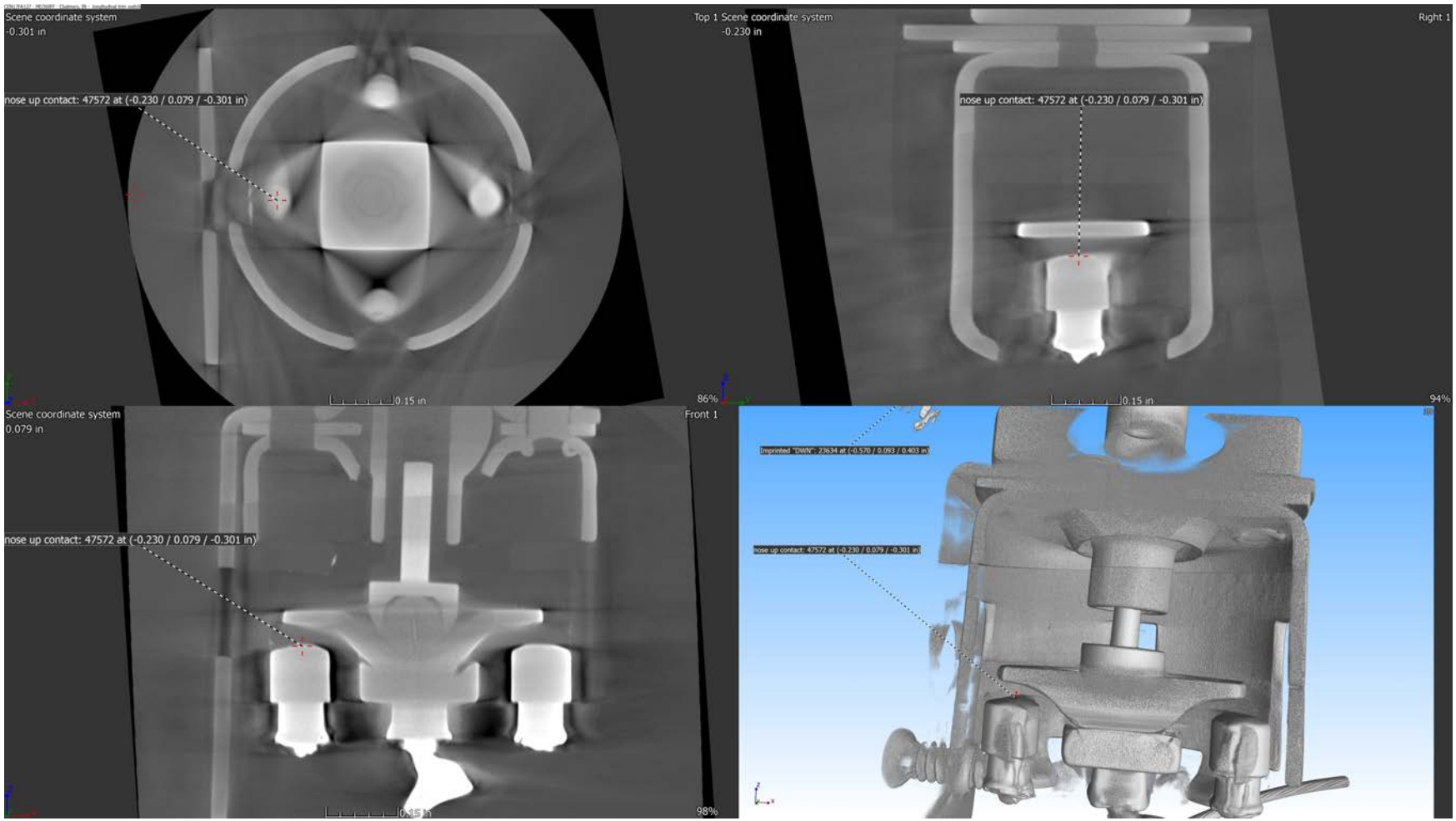

Figure 82
Trim switch – target CT – nose up contact

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